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Effects Of Content Augmentation Strategies In An Instructional Virtual Environment

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EFFECTS OF CONTENT AUGMENTATION STRATEGIES
IN AN INSTRUCTIONAL VIRTUAL ENVIRONMENT

by

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A dissertation submitted in partial fulfillment of the requirements
for the degree of Doctor of Philosophy
in the College of Arts and Sciences
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Orlando, Florida

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ABSTRACT

Content augmentation strategies (CAS) are instructional methods which specify the overlaying of content objects by content augmentation objects in order to increase the effectiveness and efficiency of instruction. The goals of this research were to build a comprehensive framework around CASs, determine the experimental effects of CASs in an instructional virtual environment (VE), and make recommendations regarding the employment and further study of CASs in instructional virtual environments. The VE experiment examined the effectiveness and efficiency impact of six different content augmentation strategies which overlayed different content augmentation objects onto four immersive VE scenarios. Sixty university students, 40 men and 20 women, executed three CAS-enhanced training missions and one no-CAS test mission. The task involved the recall and correct application of specific rules for three subtasks of a military helicopter landing zone scouting mission. The strategies included a no-strategy control condition, an arrow condition, an audio coaching condition, a text coaching condition, an arrow plus audio coaching condition, and an arrow plus text coaching condition. Statistical and decision analyses were conducted on the effectiveness and efficiency performance data. Statistically significant differences were found which supported the general superiority of the audio content augmentation strategy for these tasks. This dissertation may be the first use of a decision analysis approach for analyzing the results of behavioral data for instructional design decisions. The decision analysis approach used decision trees, simulation and optimization to obtain content augmentation strategy rankings. As this approach is normally used for course of action analysis and comparing alternative system configurations, the validity of this approach in

this context has yet to be determined. The decision analysis approach obtained plausible and similar, but not identical recommendations to the statistical approach. The decision analysis approach may constitute a limited instantiation of a proposed optimal stimulus set instructional design model which conceptually framed the experiment. Training guideline recommendations, experimental procedure recommendations, and a comprehensive framework for future research are also presented.

To La

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LIST OF ACRONYMS

AAR	After Action Review
AR	Augmented Reality
ARI	Army Research Institute
BO	Bounding Overwatch
CO	Content Object
CAS	Content Augmentation Strategy
CAT	Content Augmentation Tactics
DA	Decision Analysis
DM	Decision Maker
GOF	Goodness of Fit
HMD	Head Mounted Display
IS	Instructional Strategy
ICS	Individual Combatant Simulation
IST	Institute for Simulation and Training
IT	Instructional Tactic
ITQ	Immersive Tendencies Questionnaire
K-S	Kolmogorov-Smirnoff
LZ	Landing Zone
MAUT	Multiattribute Utility Theory
MOUT	Military Operations in Urban Terrain
NDM	Naturalistic Decision Making

OFP	Observation/Fire Post
OLM	OSS Layers Model
OSS	Optimal Stimulus Set
OSS _I	OSS from Intuition
OSS _A	OSS from Analysis
PQ	Presence Questionnaire
SSQ	Simulator Sickness Questionnaire
VE	Virtual Environment
VR	Virtual Reality

CHAPTER ONE: INTRODUCTION

Generating the optimal learning environment may be the over-arching goal of guided learning. This paper focuses on one component of the optimal learning environment generation challenge - the effects of content augmentation strategies in an instructional virtual environment. This exploratory experimental research is conceptually situated within a proposed unified framework for guided learning, a proposed Unified Field Theory of Guided Learning, and a proposed instructional design model – the Optimal Stimulus Set (OSS) Layers Model (OLM). When these constructs are combined with a novel decision analysis (DA) approach for analyzing the experimental data, the result may be a conceptually unified and mathematically supported instantiation of optimal learning environment design.

The OSS Layers Model (OLM)

The unified framework and unified field theory constructs are elaborated in the “Recommendations for Future Research” section of Chapter Five below. We begin situating the experiment which is the focus of this paper within a proposed instructional design model called the OSS Layers Model. The model is introduced here and discussed in more depth in Chapter Five.

The characteristics of an instructional design theory are (Reigeluth, 1999):

- An orientation towards design, focusing on the means to attain goals for learning and development. It is not description oriented, which emphasizes the results of given events, like the information-processing theory. Design oriented (or goal oriented)

theories are practical and useful to educators, showing them how to achieve their goals. They are *prescriptive*.

- Identification of methods of instruction, which are ways to support and facilitate instruction, and the situations in which those methods should and should not be used. These two components are necessary for all instructional-design theory and indicate that methods are situational, not universal in application.
- The methods of instruction can be broken into more detailed component methods, which provide more guidance to educators. These parts can be made up of smaller methods. The additional implication is methods have different 'kinds' of characteristics. Outcomes are dependent on the situation. 'Criteria' can be provided that the method should meet. The level of guidance can vary.
- The methods are probabilistic rather than deterministic, which means they increase the chances of attaining the goals rather than ensuring attainment of the goals. The goal of an instructional-design theory is to attain the highest possible probability of the desired results occurring.
- An instructional-design theory's goal (or design) has a value or philosophy that underlies it. Values play a key role in deciding what goals to pursue via the selection of methods offered to attain those goals.

To solve the optimal learning environment generation problem, what is needed is an instructional design theory which has the above characteristics and, in the end, explicitly specifies the stimuli (if any) which fill all dimensions of natural and artificial sensory channels available between the learner and the surrounding learning environment.

The OSS Layers Model (OLM) is proposed as an instructional design model candidate that meets these requirements. According to this model, introduced here in summary form (elaborated in Chapter Five) and without validation, the instructional designer must make analytically optimal design decisions with regard to the following logical constructs in the following sequence:

Layer 1. Learning environment (also a physical layer). The learning environment is defined as that which generates sensory stimuli for learning goals.

Layer 2. Content object(s) (also a physical layer). A content object is a learning resource which serves as the vehicle for transmitting knowledge from one human to another.

Layer 3. Content instructional strategies. An instructional strategy “represents a series of decisions “plan, method, or series of activities aimed at obtaining a specific goal” (Jonassen & Grabowski, 1993, p.20).

Layer 4. Content instructional tactics. Instructional tactics represent “specific actions which are well-rehearsed and are used to enable the [instructional] strategy” (Jonassen & Grabowski, 1993, p.20)

Layer 5. Content augmentation strategies (CAS). These are plans, methods, or series of activities aimed at implementing instructional tactics. This is the layer of interest in this paper and an experiment for determining the effects of CASs in an instructional virtual environment is elaborated in Chapters 2-5 below.

Layer 6. Content augmentation tactics (CAT). These tactics determine how the CASs will be executed.

Layer 7. Content augmentation object(s) sensory attributes (also a physical layer).

Content augmentation objects can be thought of as stimuli overlaying content objects.

Every content augmentation object has sensory attributes.

Layer 8. Learning strategies recommendations (also a physical layer). Learning strategies are the “information processing methods that people use to control their learning, which can involve processes of attending/perceiving, encoding, and retrieval” (Tessmer & Jonassen, 1988, p.34).

The optimal stimulus set constituting the optimal learning environment is defined as that stimulus set which yields the highest probability of goal success based upon what is known. For the OLM instructional design model, the OSS would consist of the combined OLM physical stimulus layers.

A novel decision analysis approach will be used to complement the traditional statistical approach in determining the OSS for the experiment. The inferential statistics approach is the approach traditionally taken by behavioral scientists to analyze human factors experiments. A proposed complementary decision analysis approach may: (1) provide additional insight into the phenomenon; (2) provide better training guideline recommendations, and; (3) demonstrate proof-of-concept for determining the analytical component of the optimal stimulus set through mathematics alone, i.e., without human intuition. That is, decision analysis may have the potential to provide a mathematical foundation for education and training. However, the use of this analysis method should be considered experimental as this is the first known instance of its use for the type of data generated in the present study.

Before performing and reporting the results of the analysis, however, it is necessary to provide a context for the experiment. This section necessarily summarizes a previous experiment (Singer, Kring, & Hamilton, in preparation, hereafter “previous experiment”) which is replicated and extended in the present experiment.

Previous Experiment

One of the most important learning contexts is military training which is recognized as an important national priority. As with all the military, U.S. Army soldiers are tasked with a growing array of complex and challenging requirements. Dismounted soldiers, in particular, must possess knowledge and skills that are instantly accessible to survive and excel in warfare operations today. One approach that has already proven effective for training is the use of virtual environment (VE) simulations to teach new skills and allow soldiers to practice these skills in an interactive, dynamic fashion. Examples include the Virtual Sand Table - a computer-generated version of the traditional sand table exercise which gives personnel the opportunity to practice military doctrine in a hands-on manner (Wisher, Macpherson, Abramson, Thornton, & Dees, 2001) and more immersive systems that allow soldiers to navigate through virtual settings with head mounted displays (HMDs).

The rise in VE simulation can be attributed to the numerous benefits over traditional, “real world” training programs or other computer-assisted instruction. First, “only VEs can create the illusion of being in another place” (Winn, Windschill, Fruland, and Lee, 2002). Second, VEs

afford greater flexibility to precisely alter learning environments and mission conditions. An example of this flexibility is the ability to implement instructional strategies and tactics that are unavailable, or difficult to implement, in a real world setting. Third, because every stimulus generated can be controlled and recorded, they can afford superior data collection abilities. For example, VE systems are well suited to capture and store performance data. Fourth, evidence shows that the effectiveness of VE training is equivalent to, or in some cases better than, real world training (Rose et al., 2000; Todorov, Shadmehr, & Bizzi, 1997). In summary, VE holds promise as a major training tool in many areas, and has already been demonstrated or used for training many different tasks or jobs: pilots (e.g. Bell & Waag, 1998; Lintern, Roscoe, Koonce, & Segal, 1990); ship navigators (Hays & Vincenzi, 2000; Magee, 1997); emergency personnel (Bliss, Tidwell, & Guest, 1997); first responders to bio-terrorism (Stansfield, Shawver, Sobel, Prasad, & Tapia, 2000); and space mission ground control staff (Loftin, Wang, Baffes, & Hua, 1992).

Because “there is a need for a principled program of research needed to discover how (to) make best use of VR for instructional purposes” (Psotka, 1995, cited in Brown, 1999), specific ways to enhance the training effectiveness and efficiency of VE systems for dismounted soldiers and the leaders of small groups of these soldiers is a goal of this research. The primary goal is to investigate VE-specific capabilities that can enhance learning and skill levels for important or critical dismounted small unit leader tasks. This approach is particularly important because of the increasing cognitive loads being imposed on the squad and platoon leaders through the Land Warrior and Objective Force Warrior programs (National Research Council, 1997). Learning to execute activities within the three most significant infantry missions - move, attack, and defend -

(National Research Council, 1997) may be important to the success of those missions, and will be even more important as the information load of the small unit leader increases. One way to keep technology-based increases in information flow within the cognitive resource bounds of the small unit leader is to reduce the load required for the successful performance of other common tasks through improved training such as those afforded by VE training. Serendipitously, one way to research future training within the increased technology context is with VE systems that can represent unfielded equipment configurations. Thus, VE technologies can address present *and* future training requirements.

VE-based training is constrained by many factors, including cost. Because VE-based instruction will continue to be relatively expensive for the near future, the focus for the line of research of the previous and present experiments is on initial skill training. The goal of this research is to efficiently move someone from declarative knowledge (being able to answer questions about rules or concepts) through slow and minimally competent, essentially correct performance to faster, more-competent, and less-effortful expert performance. In psychological terms, this means moving the learner from the declarative state knowledge of a skill into the procedural knowledge of the skill, and from more effortful and error-ridden executive-controlled processes toward automaticity. Procedural knowledge is about how to do things, and automaticity refers to processes that are automatic, easily initiated by selected classes of stimuli and that proceed with little probability of error and minimal effort.

The first step to facilitating this cognitive shift by the researchers of the previous experiment (Singer, et al., in preparation) was to identify a group of common small group leader tasks, based

on an assessment of activities necessary for US Army operations, as candidates for enhanced VE-based training with instructional features. They defined instructional features as “elements of training devices that can improve training efficiency on individual tasks” (Sticha et al., 1990, p.17). Second, informed by empirical findings and theoretical work, they defined and conceptually integrated instructional goals, strategies, tactics, and features to provide a reasonable degree of order and clarity to the thick but fragmented literature. Third, they identified several specific instructional features which enabled the implementation of instructional tactics within a specific instructional strategy – *provide cueing systems* - that were judged as promising in improving the effectiveness and efficiency of VE-based training and examined their potential for use in dismounted soldier VE training systems. Although novel tasks are better learned under conditions of guided and prompted practice (Romiszowski, 1993), more detailed design principles for these features are not available for any learning environment, let alone VEs. Of those identified as promising, the features selected for exploratory experimentation were oral coaching and a direction-indicator arrow, primarily because both are commonly used cueing strategies and are easily implemented in VEs. Finally, experimental research was conducted to test the effects of these two instructional features on important small group leader task accomplishment.

It should be noted that augmented reality (AR) – “augmenting natural feedback to the operator with simulated cues” (Milgram, 1994) – might be phenomenologically similar to VE. Instead of altering “natural” virtual feedback with simulated cues, VEs can alter “*natural-looking*” feedback with simulated cues. AR is essentially overlaying the real world with computer-generated stimuli thereby artificially altering the (natural) environment. Therefore, instructional design lessons

learned in VEs may also transfer to the growing number of less expensive and more portable AR training systems. This line of research might then suggest requirements generation and implementation guidelines for instructional features in future VE and AR training systems and programs.

Previous Experiment Task Selection

Soldiers use a large number of specific types of knowledge, skills, and abilities in the course of operations. In their search for appropriate VE tasks, the researchers in the previous experiment examined the Jacobs et al. (1994) study that analyzed tasks and activities of individual combatants in order to recommend behavioral and technological requirements for VE training.. The study analysis revealed 230 unique activities associated with 67 Soldier tasks, and rated each activity according to its primary and secondary sensory modality (auditory, visual, tactile, and force feedback), as well as the required effector—the primary method by which the response of the soldier is monitored and injected into the VE simulation (hand, finger, head, body, speech, and instrumented objects). The study also rank ordered these activities according to the frequency of the activity in various tasks, and how well VE technology could support the activity in training systems. This study provided the basis for selecting relatively typical and reasonably complex cognitive activities that can be quickly trained in order to be used for VE training research. Of the 67 Soldier tasks, the analysis conducted in the previous experiment concluded that rehearsal of a helicopter landing zone scouting mission met the requirements for being typical, complex, quickly-trained, required interaction with the environment, and was VE-

implementable. It was therefore selected as an appropriate task for studying different training techniques in an immersive virtual environment.

Previous Experiment Conceptual Framework

Singer, et al., (in preparation) argued that instructional goals, instructional strategies, instructional tactics, and instructional features are not the same, but do relate to one another in structured and supportive relationships. First, there is the overall objective, or the *instructional goal*. If we accept that directed learning is the purposeful transfer of information, knowledge, skills, abilities, and/or attitudes from one source (e.g., instructor, computer software, simulation, or other system) to an individual or group, then the purpose of a directed learning program can be termed the *instructional goal*. This purpose has also been referred to as the instructional objective, outcome, or task. Second, directed learning programs must have one or more explicit approaches, or *instructional strategies*— a “plan, method, or series of activities aimed at obtaining a specific goal” (Jonassen & Grabowski, 1993, p.20). *Instructional tactics* are “specific actions which are well-rehearsed and are used to enable the strategy” (Jonassen & Grabowski, 1993, p.20). Tactics are maneuvers or manipulations that are used to change a learner’s knowledge state which enables the instructional strategy. Finally, as introduced above, *instructional features* are “elements of training devices that can improve training efficiency on individual tasks.” (Sticha et al., 1990, p.17). They are a variety of tools and/or techniques that instructors can use to support and implement the instructional strategies and tactics. Applied to the experimental task, these concepts could be organized hierarchically, as shown in Figure 1.

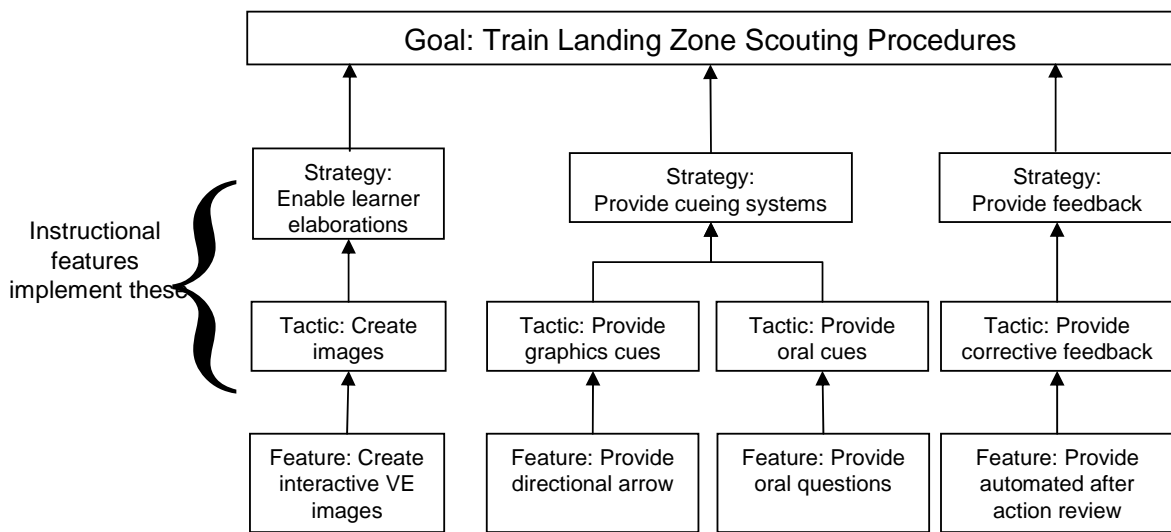


Figure 1. Conceptual relationships among instructional strategies, tactics, and features from the previous experiment

Previous Experiment Results

Although the audio intervention appeared to be generally superior to the arrow intervention in the Singer, et al. exploratory experiment, few significant effects were found. The researchers hypothesized the reasons for this may include: (a) the feature itself did not cognitively assist as anticipated, and/or; (b) the participants did not understand the intervention, and/or; (c) there were experiment methodological weaknesses. In order to clarify and better understand the training impact of these kinds of interventions in instructional virtual environments, the present experiment was designed to replicate, improve, and extend that experiment.

Present Experiment

As a follow-on to the Singer et al. (in preparation) study, the goals of the present experiment were to (1) further strengthen the conceptual framework surrounding content augmentation strategies (“instructional features” in their model); (2) replicate and extend the previous experiment, and; (3) if possible, derive general training guidelines for the use of these strategies.

For the current study there were major additions to the conceptual framework, minor changes in the experimental procedures and outcome measures, and a major addition to the analysis procedure. In order to leverage insights and resources from the previous study, there were no changes to the experimental tasks.

Conceptual Improvements

The researchers from the previous experiment made a contribution to the literature in that they attempted to explicitly relate the instructional features of learning environments to instructional strategies and tactics. There are at least 25 different classes of what is commonly known in the military training community as instructional features (Sticha et al., 1990), including those which make the trainer’s job easier but do not directly impact OSS generation. Only one of these - automated cueing and coaching (implemented as semi-automated cueing and coaching by the experimenter) – is the focus of the research in this paper. Therefore, the umbrella term “instructional features” is not very useful when seeking the precise description of a precise prescription necessary within the OSS Layers Model, and the term content augmentation

strategies adopted to better relate these strategies to the increasingly more prominent augmented reality and shareable content objects concepts.

Figure 2 shows a proposed OLM modification and extension of their framework when applied to the current study. Simply put, a learning situation is defined as a specific learning environment where an instructional goal is pursued under constraint. In order to attain the instructional goal, the learning environment affords the generation of certain content objects (here, the interactive VE scenarios) and the implementation of instructional strategies.

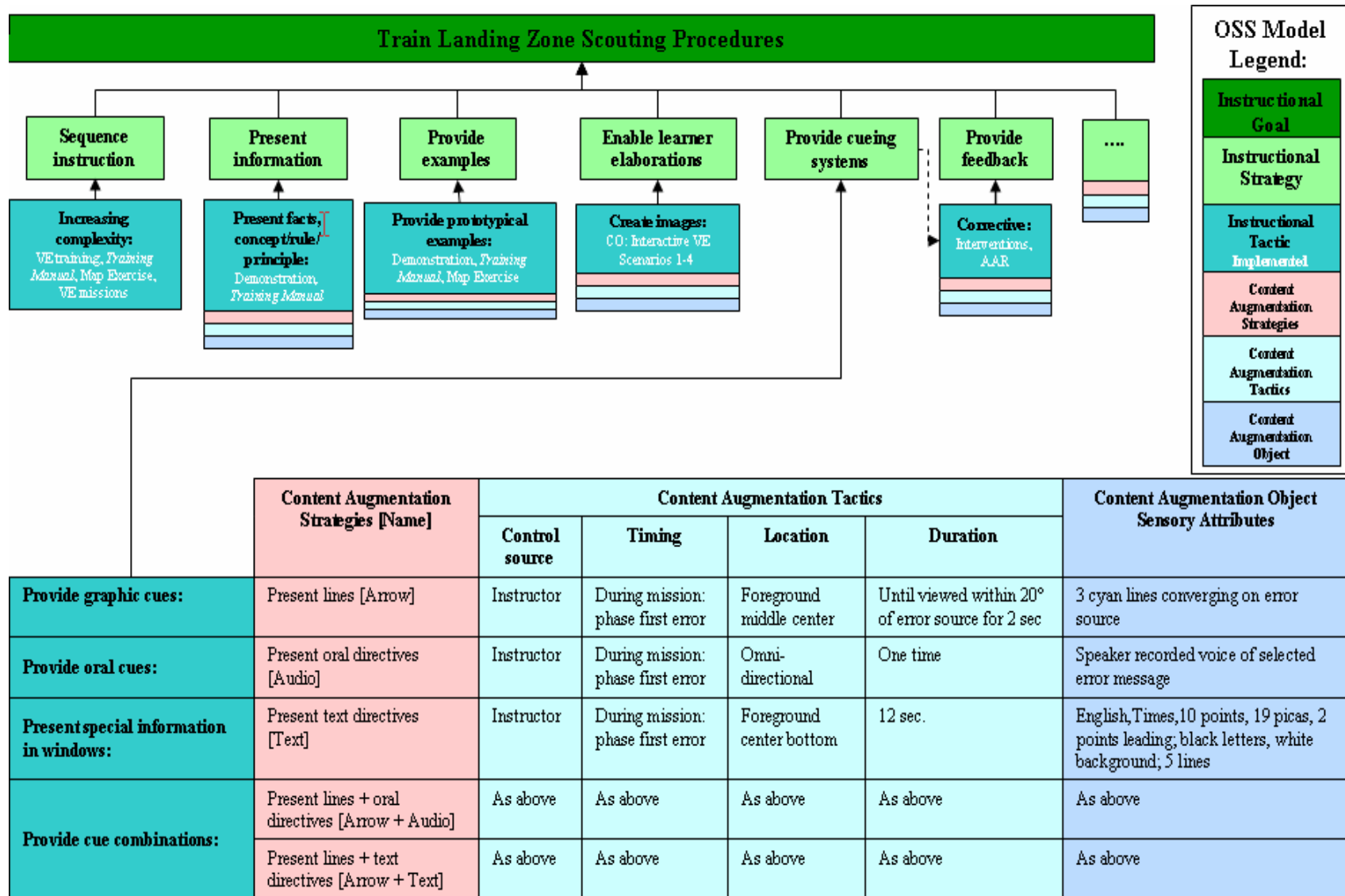


Figure 2. Conceptual relationships among the OLM components when applied to the present CAS experiment

Within each strategy, certain instructional tactics are enabled which implement the strategy. The content, defined as the sum total of the content objects (e.g., SCORM objects (Advanced Distributed Learning, 2004)), can then be modified, or augmented, through content augmentation strategies, which is the layer of focus of the present study. Implementing these content augmentation strategies, content augmentation tactics control the generation of content augmentation objects which have sensory attributes. For the previous and present VE experiments, all the variables above and below the CAS layer were kept constant for every participant and the impact of the various CASs on subtask effectiveness and efficiency was examined.

Experimental Improvements

Several changes were made to the present experiment in order to build upon lessons learned and extend the experiment with an additional CAS – text coaching.

First, the sensory attributes of the *present arrow* CAS from the previous experiment indicated just the general direction of, but not the distance to, the error source (see Figure 3), and therefore may not have localized the error source precisely enough to be useful to the participant.

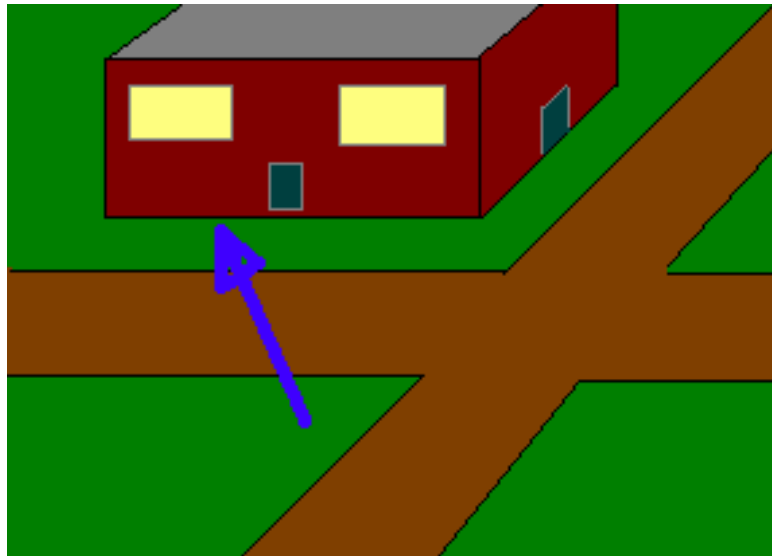


Figure 3. Implementing the arrow CAS in an early prototype system

To remove some of this ambiguity, a different direction-indicating graphic cue CAS – *present lines* - was designed and used for this experiment. Here, the *location* CAT in the field of view consisted of converging cyan lines appearing in the foreground center bottom of the participant's field of view, with a changing orientation that always pointed toward the source of the error (see Figure 4).

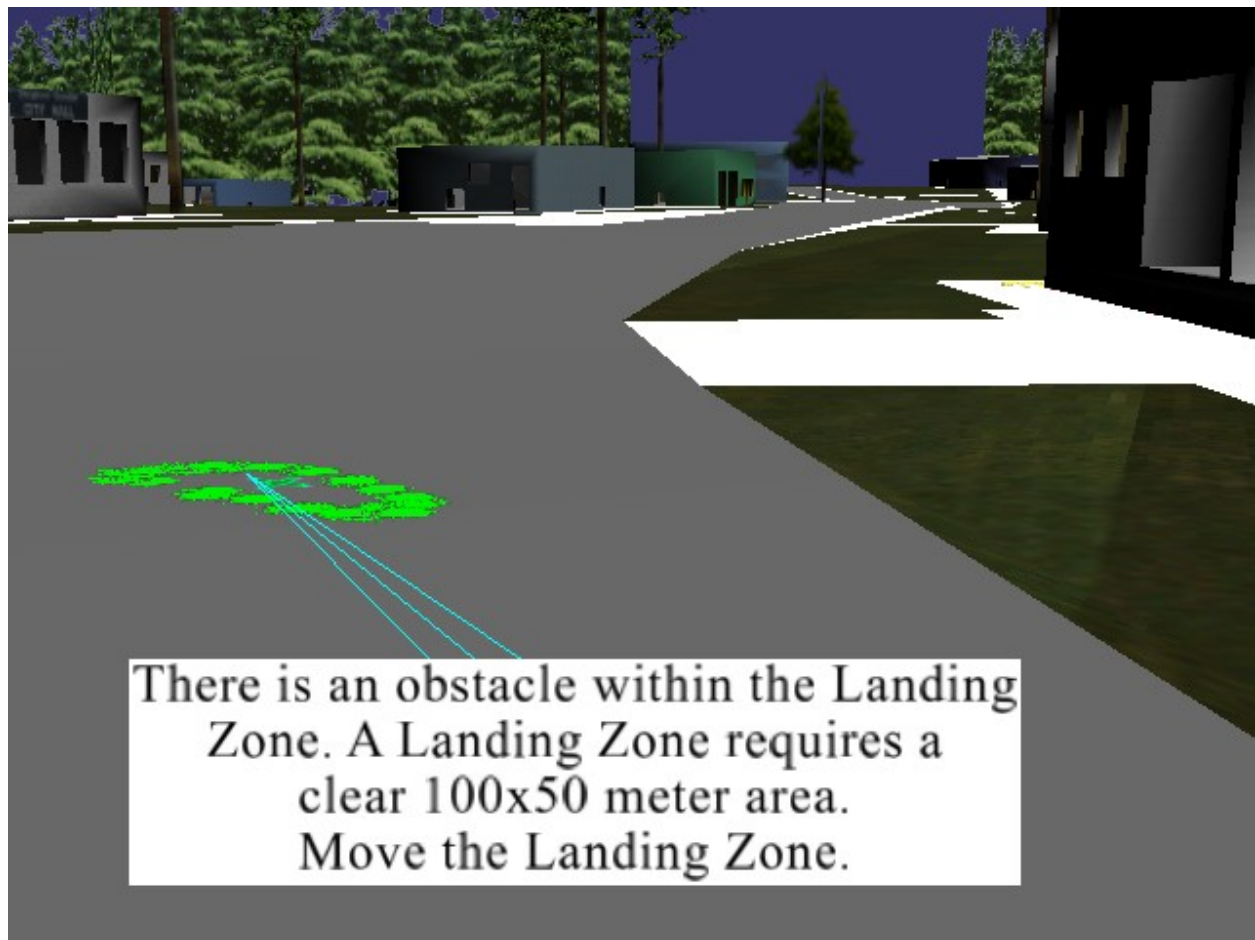


Figure 4. Participant's view of the arrow + text CAS in the experiment

Second, because it appeared many of the participants did not understand the gist of the thought-provoking questions being asked for the audio coaching condition, the form of the audio coaching was changed from question-based to directive-based. Each directive had the following format: (a) you have committed an error; (b) here is how to do it correctly, and; (c) do the task activity again.

Third, in order to mitigate any experimenter confounding during the audio coaching or arrow + audio coaching strategies, the intervention was taped and played back rather than being spoken live.

Fourth, it must be noted that the maximum time allowed in the VE experiments was limited to twelve minutes to ensure minimal simulator sickness by the participants. Because of the 12-minute mission time limit but no time limits on the subtasks, not all participants finished all subtasks during the VE mission in the previous experiment. It was believed the failure to advance to the latter phases of each time-limited mission may have affected the scores for those phases, rather than reflecting the actual level of expertise for those activities. To mitigate this effect for the current experiment, strict time limits were enforced for each of the three mission phases.

Fifth, on the experimenter's scenario control monitor during each mission, 5- and 50-meter circles surrounded participant marks for bounding overwatch (BO) and observation/fire post (OFP) positions. Landing zone (LZ) positions were surrounded by 7- and 50-meter circles (see Figure 5) due to the unique nature of the proper LZ shape. These circles were not visible to the participant during the VE missions, but were visible during the AAR of the mission. The circles provided several advantages over the previous experiment. First, it enabled the experimenter to make better judgments of distance-related errors and therefore better time the intervention during the mission. Second, it provided more precise distance-related feedback to participants during the AAR. Third, it enabled more precise post-mission scoring by the subject matter experts for distance-related errors.

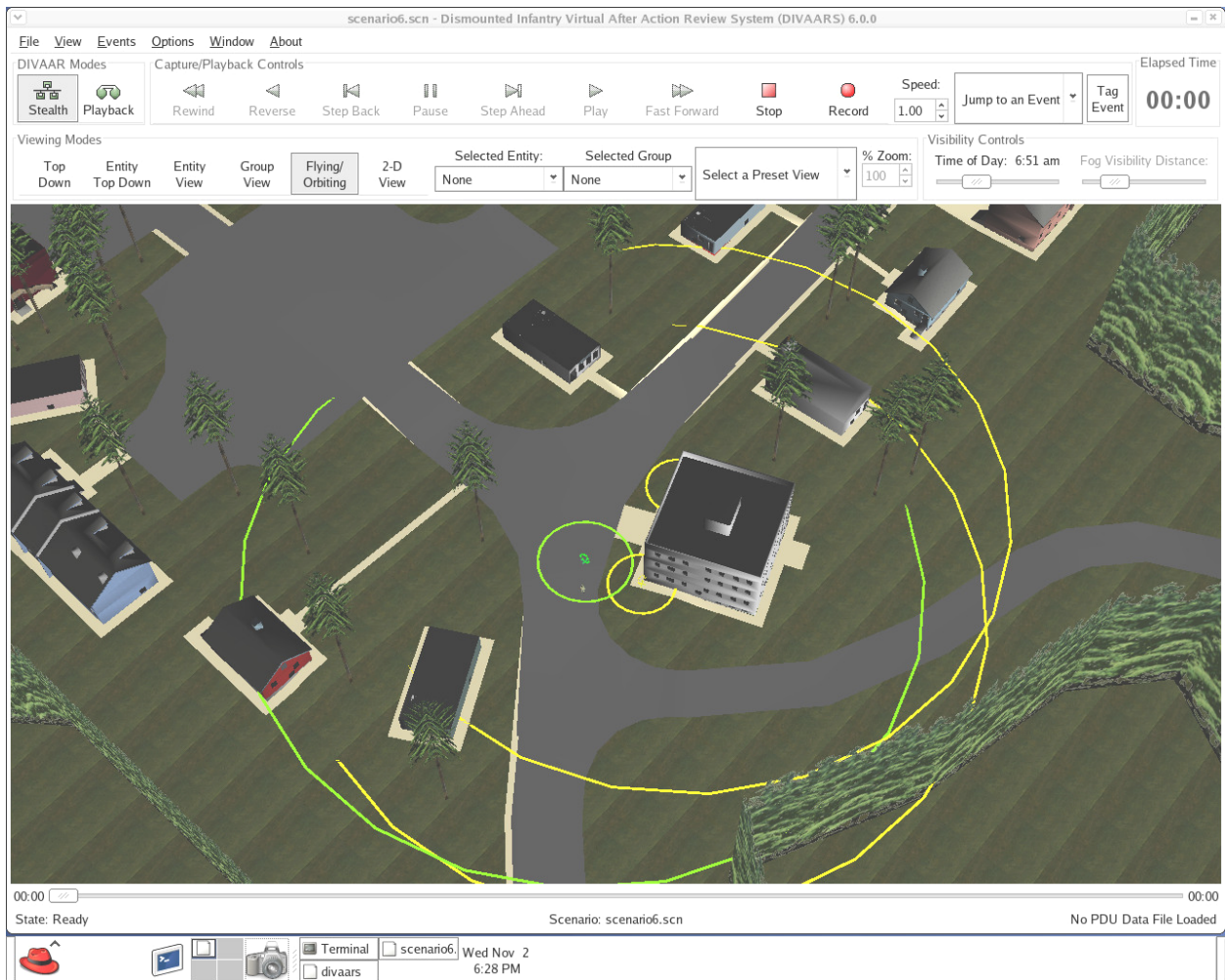


Figure 5. Screenshot of the AAR system showing concentric distance circles around the participant's marks of Figure 4. Gaps in the circles are due to elevation differences.

Sixth, an additional independent variable was added to the experimental design - a window with the appropriate oral directive message in text. Like the arrow CAS, the text window stimulus appears on command in the field of view (see Figure 4 above for example) immediately after the first error of each mission phase.

It was hoped these changes would result in more significant interactions for the present experiment than the previous experiment.

Hypotheses

This additional text coaching CAS independent variable resulted in a counterbalanced 2 x 3 factorial between-subjects experimental design (Table 1) (Gravetter & Forzano, 2003).

Table 1. The present CAS experimental design

		Arrow Main Effect	
		Arrow	No Arrow
Main Effect	Audio coaching strategy	<i>n=10</i>	<i>n=10</i>
	Text coaching strategy	<i>n=10</i>	<i>n=10</i>
	No coaching strategy	<i>n=10</i>	<i>n=10</i>

There were ten randomly assigned participants in each of the six experimental CAS conditions: no strategy, arrow, audio coaching, text coaching, arrow + audio coaching, and arrow + text coaching.

In predicting the effects of these CASs prior to the experiment, the nearly-identical research of the previous experiment and the literature review in Chapter Two led to the following hypotheses.

- Hypothesis One: Participants receiving any augmentation will outperform those receiving no strategy.
- Hypothesis Two: For single augmentation conditions, participants receiving audio coaching will outperform participants receiving text or arrow augmentation.
- Hypothesis Three: For single augmentation conditions, participants receiving text coaching will outperform participants receiving arrow augmentation.
- Hypothesis Four: Participants receiving multiple augmentations will outperform participants receiving a single augmentation.

CHAPTER TWO: LITERATURE REVIEW

The central focus of this research is to test the effect of decreasing the cognitive load on an increasingly information-loaded small unit leader by improving the training of other activities to near-automatization. This training is achieved by augmenting the instructional VE to maximum advantage. If augmenting the VE through CASs can assist in this training, the key research questions to be answered are: under what conditions will they help, how much will they help, and why do they help?

Wickens (2002) proposed a model to predict performance under dual task interference conditions. This model proposes four categorical and dichotomous dimensions that account for variance in time-sharing performance: processing stages, perceptual modalities, visual channels, and processing codes. An analysis of the experimental VE subtasks within this model may help predict the impact of CASs on learner performance and generate hypotheses to be tested during the experiment.

In terms of processing stages, the experimental subtasks are similar and involve elements of all three stages of the model: perception, cognition, and response. The participant must perceive the environment, estimating distances and spatial relationships accurately. While keeping the goals of the subtask in mind, they must have cognitive situational awareness and understanding by correctly recalling and applying the rules of the subtask they had been trained on earlier. They then must demonstrate this understanding with correct responses: painting a circle on the ground and putting an X inside at the correct locations. The participants must demonstrate expertise to

criteria for all three stages in the training in order to advance to the mission phase where the data is collected. However, while the perception and response activities are relatively simple and trained to near-automaticity, differences between participants may arise in the cognitive recall of the subtask rules which must be kept in working memory during mission performance.

With regard to audio or visual perceptual modalities of the Wickens (2002) model, the subtasks are almost exclusively visual. The only auditory stimuli generated in the VE were the sound of the paint shots and a thud heard when the participant collided with an object in the environment.

In terms of focal or peripheral visual channels, the head mounted display enabled a relatively narrow field of view; therefore, the visual channel used was nearly exclusively focal, rather than ambient and peripheral, and was consistent across subtasks.

The processing code dimension defines the distinction between analogue/spatial processes and categorical/symbolic (usually linguistic or verbal) processes, important because each depends on separate resources. This dimension applies especially to conflicting resource demands in responses. In this case, the experimental subtasks require the same response of physical position marking, rather than talking about position marking, and therefore are analog/spatial in nature and consistent across subtasks.

It appears then, that any differences in performance across CASs might be found at the intersection of cognitive resources required (specifically working memory capacity (Miller, 1956)) for the subtasks and the additional resource load imposed by the various CASs. Baddely

(2002) developed a model of working memory which contains the central executive with the visuospatial sketchpad and the phonological loop. Components of the subtasks such as interpreting the display, recalling the paper map mission, recalling the visuospatial subtask rules and formulating navigational ideas all occupy the visuospatial sketchpad to the point where capacity may be an issue for these subtasks. Further, working memory requires rehearsal in order to maintain its contents. Therefore, the CASs may somehow overburden, interfere, promote, or otherwise affect the capacity and rehearsal of the visuospatial sketchpad and subsequent subtask performance.

Assuming this framework, hypotheses can now be generated about the effects of these CASs on performance. Looking for an omnibus effect, we can hypothesize that any CAS will indeed promote performance. Because additional relevant information is injected into the environment, it is assumed that any feedback which increased the salience of stimuli important for rule recall and application would be significantly superior to those control condition participants learning only through practice (Boldovici, 1992).

Hypothesis One: Participants receiving any augmentation will outperform those receiving no strategy.

Which strategy will be most helpful in increasing performance? In the previous experiment which compared an arrow strategy to an audio coaching strategy, the audio coaching was generally superior to the arrow strategy, and significantly so for the BO subtask. As the

experimental situation will be nearly identical for the present experiment, it is reasonable to assume the same effect in the present experiment.

Hypothesis Two: For single augmentation conditions, participants receiving audio coaching will outperform participants receiving text or arrow augmentation.

To fully order the available strategies, the arrow and text coaching strategies need to be compared as well. It is reasonable to conclude that the more specific feedback from text coaching, though perhaps more distracting and time-consuming to read during the mission, would overcome the less specific feedback from the arrow strategy and lead to Hypothesis Three.

Hypothesis Three: For single augmentation conditions, participants receiving text coaching will outperform participants receiving arrow augmentation.

For the arrow + audio coaching and arrow + text coaching strategy conditions, would these separate cues in combination enhance each other synergistically or somehow negate each other?

Multiple channel communication involves the simultaneous presentations of stimuli through different sensory channels. Moore, Burton & Myers' (2004) review of the multiple channels communications literature led them to conclude,

the overall evidence on the effectiveness of single-channel versus multiple-channel presentations is confusing at best. The human information processing system appears to

function as a multiple-channel system until the system capacity overloads. When the system capacity is reached, the processing system seems to revert to a single-channel system....Adding information channels does not enlarge the system....Conflicting research results are also present concerning the use of redundant information presented across two or more channels (p.998).

Cue summation theory (also known as audio-visual theory) is the general theory positing that the more cues that are given through various communications channels, the more learning occurs (Moore et al., 2004). For example, as long as the message is congruent between channels, it is thought that the channels would reinforce each other. Hartman (1961) indicated that if audio and visual messages were identical or closely related (in the present experiment the messages are identical), they complement each other to form one thought and improve learning. Van Mondfrans and Travers (1964), however, concluded that humans cannot receive more information if exposed to two or more sources simultaneously than if exposed to just one source. In reviewing the literature, Moore et al. conclude that cue summation theory may not be valid in some contexts. With the cue summation literature being mixed and not knowing whether multiple cues would help in the context of these subtasks and/or VEs, but was worth investigating, it was hypothesized that these complementary cues would improve performance.

Hypothesis Four: Participants receiving multiple augmentations will outperform participants receiving a single augmentation.

CHAPTER THREE: METHODOLOGY

Participants

Sixty participants were recruited from the University of Central Florida student population, and paid or given class credit for participation. A student randomly signed up online through the university's Department of Psychology website by selecting a time slot available. The average age of participants was 19.9 years, and there were 40 males and 20 females.

Consistent with the previous experiment, the goal was to compare the effectiveness and efficiency differences in learning based upon the different CAS used. An additional independent variable was added to the experimental design - a window with the appropriate oral directive message in text. Like the arrow and audio coaching interventions, the text window appears on command in the field of view immediately after the first error of each mission phase. Only the first error received feedback in order to avoid the "crutch effect" (Boldovici, 1992), where knowledge of results may actually reduce the trainer's effectiveness in preparing the learner for the operational situation. Similar approaches have proven successful in simulator-based flight training (Skitka, Mosier, & Burdick, 2000; Loftin, Wang, Baffes, & Hua, 1992).

Upon arrival at the experiment location, participants were assigned to their group based on a Latin squares random assignment scheme that counterbalanced experimental condition, scenario order, and experimenter experience.

Apparatus

Virtual Environment

The experiment required the use of a network of six personal computers for rendering VE scenarios, one networked large screen plasma display for AAR administration, and one stand-alone personal computer for questionnaire administration. MotionStar™ sensors were used to track the participant's physical movements, and Virtual Reality VR8™ head mounted displays presented head-slaved, computer-generated, stereoscopic color imagery to the participants (see Figure 6).



Figure 6. VE experimental apparatus

Stereo sound for object collision, paintshot noises, and audio coaching were provided through earphones attached to the HMD. The software was written by the Institute for Simulation and Training using Performer, C++, and Java.

Two real-world environments were digitally modeled for interactive VE use: the Shugart-Gordon Military Operations in Urban Terrain (MOUT) site at Ft. Polk, Louisiana, and the McKenna MOUT site at Ft. Benning, Georgia. Each of these digital environments was slightly altered for experimental use, and had two different starting points established. This allowed each environment to be used twice in the four-scenario experimental series.

AAR Plasma Screen

After Action Reviews of the same error segments used during the mission were presented on a 42-inch plasma screen. Figure 5 above shows how these circles appeared.

Questionnaires

Questionnaires were administered before, during, and after the sequence of VE scenarios. All questionnaires were implemented in a Microsoft Accesstm database on a stand alone personal computer for ease of administration and analysis. The *Biographical Questionnaire* (Singer et al., 2004, Appendix B) asked standard questions about participant characteristics and experience, primarily with video games and virtual environments. The *Simulator Sickness Questionnaire* (Kennedy, Lane, Berbaum, & Lilienthal, 1993, Appendix C), probes the level of motion sickness symptoms. This allowed a continuous monitoring of the participant's physical health during the

experiment (see below). Other questionnaires include the *Presence Questionnaire (PQ)*; Witmer & Singer, 1998, Appendix D) and the *Immersive Tendencies Questionnaire (ITQ, V4)*; Witmer & Singer, 1994, Appendix E). The PQ addresses the participant's level of self-perceived immersion and involvement in a particular experience or episode, while the ITQ addresses the participant's general tendencies toward immersive environments and involvement.

Procedure

Experimental Procedure

The detailed *Experimenter's Protocol* is presented in Appendix A and summarized here. Once the participant entered the room, they received a verbal overview of the experiment. As is required for ethical treatment of experimental participants, the purposes of the research were explained to each participant and their questions were answered to their satisfaction. They then viewed a 4-minute demonstration of a shortened VE mission on the AAR plasma display and signed a standard experimental consent form.

Background information about the participants was then collected on the Biographical Questionnaire (Appendix B).

Each participant was then trained to established criteria on the requisite VE and military tasks. The training began with simple movement techniques in the VE, and the use of a virtual paint

gun for marking placements in the VE. The U.S. Army rules and doctrine for movement, posting, and selection of a helicopter landing zone were taught. Participants were also instructed on how to read topographical maps, including interpreting the markings for roads, clearings, flowing water, and other obstacles from the maps of the virtual databases. Participants were tested to an established criterion on correct knowledge of features (Appendix C), and application of rules, before being allowed to participate in the VE missions.

Each of the four missions contained three parts: mission paper map planning, mission execution in the VE with the interventions, and mission after action review. First, the mission goal was briefed to the participant, and a paper map of the exercise area was presented. The participant was allowed 10 minutes to use the map for marking a platoon's bounding overwatch (BO) positions along a participant-chosen route to the participant-selected landing zone (LZ), also marked on the map. With the goal of protecting the marked landing zone, the participant then marked a required minimum of two observation/fire posts (OFPs). No instruction or feedback was provided during the mission paper map portion of the mission. After completing an SSQ, the participant entered the VE and moved through the scenario, ostensibly performing the same tasks performed with the paper map. Participants were instructed that if the VE presented characteristics that violated the instructed doctrine, they were to re-evaluate the situation and mark an alternative BO path, LZ location, and/or OFP sites. During the VE mission the appropriate CAS was injected in to the VE.

For the arrow CAS, the *duration* CAT (refer to Figure 2) consisted of the lines remaining in the field of view until the participant shifted their gaze to within a 20-degree deviation from the

target location for 2 seconds, whereupon the lines disappeared from view. Just prior to beginning the mission the participant was advised, “You might be shown converging lines during the exercise. They are there to help you by pointing out where performance could be improved. Immediately notice where they converge, and consider whether you have done the last few activities correctly. The lines should disappear after about two seconds.” If the participant did not gaze in the manner in which they were instructed in order to remove the lines, the lines remained in the field of view.

For the text or audio CASs, based upon common errors made during pilot testing, there were twenty-three possible feedback directives which could be used by the experimenter (Figure 7). The CAS objects were injected into the VE when the experimenter clicked on the appropriate button (see Figure 8) immediately after the first error of each subtask phase.

Coaching Record for AAR

Scenario #: ____ Exp. Initials: ____

Date: _____ Participant #: _____

Condition: (#1)Control (#2)Arrow (#3)Coaching-Auditory (#4)Coaching-Text (#5)Arrow + Coaching-Auditory (#6)Arrow + Coaching-Text

Do only the first mistake in each phase during mission or AAR. If no error, no feedback during mission, affirmation during AAR.

Topic Area	Label	Time	Coaching Phrase for Unsatisfactory Action
Administration			
Progress Toward Objective	Admin1:Quicker		You are not working fast enough. Move as quickly as possible to complete this phase of the mission.
	Admin2:BO>LZ		Please stop the Bounding Overwatch activity and begin the Landing Zone placement phase of the mission.
	Admin3:LZ>OFP		Please stop the Landing Zone activity and begin the Observation Fire Post placement phase of the mission.
Erase X Only	Admin4:Erase		You did not erase the incorrect mark. Erase the X only.
	Admin5:Color		You have used the wrong splat color. Use yellow for Bounding Overwatch, green for Landing Zone, and red for Observation Fire Posts. Correct your incorrect mark.
	Admin6:Oops		Please disregard the previous message, it was presented in error.
Environment Inspection			
Threats	E1:>FOF		You are not scanning the entire environment for threats. Check for threats within 100 meters.
Bounding Overwatch (5 min. max)			
BO Spacing	BO1:>50M		Your last bounding overwatch position is more than 50 meters from the previous one. Redo it.
Cover & Concealment	BO2:CovCon		Your last bounding overwatch position does not provide adequate cover and concealment. Redo it.
Field of Fire	BO3:FOF		This bounding overwatch does not provide adequate fields of fire. Check the field of fire from the last BO position
DOCUMENT Overall Comments			

FOLLOW AAR FORMAT – WHAT HAPPENED, WHY THAT WAY, HOW TO IMPROVE NEXT TIME!!
DO NOT AD LIB – FOLLOW SCRIPTED COACHING PHRASES – ENTER ADDITIONS/ELABORATIONS ON SHEET!
AFFIRMATION: PARAPHRASE QUESTION PROBE TO SAY THE ACTION WAS CORRECTLY PERFORMED.

Figure 7. Coaching phrases for audio and text CAs



Landing Zone (4 min. max)	Label	Time	Coaching Phrase for Unsatisfactory Action
Adjacent to Urban Area	LZ1:VicCtr		This landing zone is too far from the center of the village. Move the Landing Zone closer.
	LZ2:Bigger		This Landing Zone area is bigger than needed. A Landing Zone requires a clear 100x50 meter area. Reduce it.
	LZ3:Smaller		This Landing Zone area is smaller than required. A Landing Zone requires a clear 100x50 meter area. Increase the area.
LZ Clearance	LZ4:LZClose		There is an obstacle within the Landing Zone. A landing zone requires a clear 100x50 meter area. Move the Landing Zone.
	LZ5:YTop14		The distance between the marks at the top of the Landing Zone is incorrect. The distance should be 14 meters, or 14 steps. Redo these marks.
	LZ6:YMid14		The distance from the top of the Y to the middle mark is incorrect. The distance should be 14 meters, or 14 steps. Correct the distance.
	LZ7:YBott7		The distance from the middle mark to the bottom of the Y is incorrect. The distance should be 7 meters, or 7 steps. Correct the bottom mark.
	LZ8:YBottAlign		The middle and bottom marks in the Y should form a perpendicular line to the top marks. Adjust the bottom mark.
DOCUMENT Overall Comments			
Observation Fire Post (3 min. max)			
Clear Observation of Approaches	OFP1:ObservFOF		Observation & Field-of-Fire for enemy approaches is inadequate from this Observation Fire Post. Reposition the Observation Fire Post.
	OFP2:Prot		This observation fire post does not directly cover or protect the landing zone. Reposition the Observation Fire Post.
Overlapping Fields of Fire	OFP3:FOF/Ovrlp		This observation fire post does not have an overlapping field of fire with an adjacent observation fire post. Add another OFP.
	OFP4:ApprCov		At least one approach to the landing zone is not covered by an observation fire post. Add another Observation Fire Post.
Sufficient Cover	OFP5:CovCon		This observation fire post does not have sufficient cover and concealment from threat areas or approaches. Reposition this Observation Fire Post.
DOCUMENT Overall Comments			

FOLLOW AAR FORMAT – WHAT HAPPENED, WHY THAT WAY, HOW TO IMPROVE NEXT TIME!!
DO NOT AD LIB – FOLLOW SCRIPTED COACHING PHRASES – ENTER ADDITIONS/ELABORATIONS ON SHEET!
AFFIRMATION: PARAPHRASE QUESTION PROBE TO SAY THE ACTION WAS CORRECTLY PERFORMED.

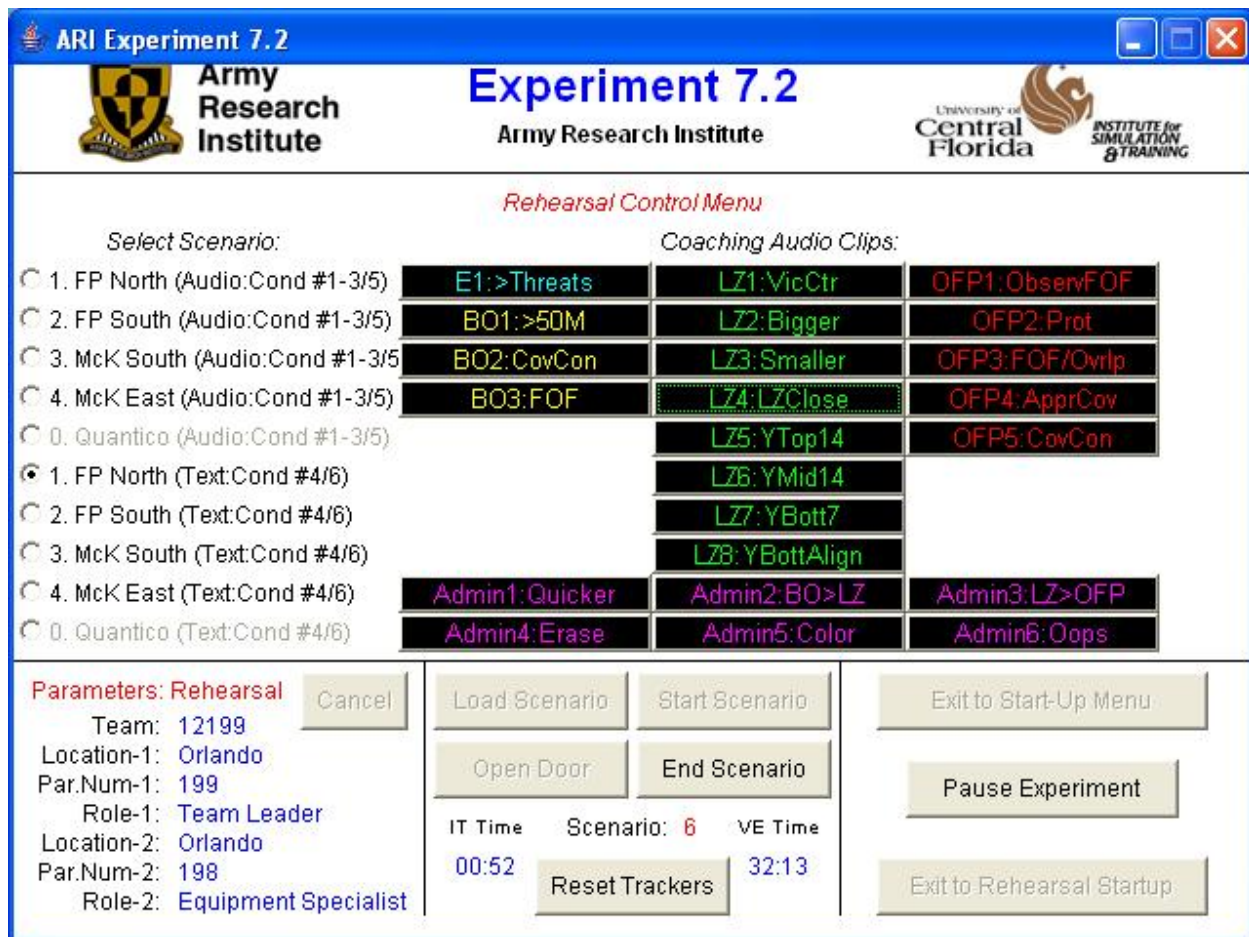


Figure 8. Screenshot of experimenter's control screen

Six of these directives were administrative (e.g., “Please stop the Bounding Overwatch activity and begin the Landing Zone placement phase of the mission.”). One concerned general environmental inspection and could be invoked at any time, three concerned the Bounding Overwatch subtask, eight concerned the Landing Zone placement subtask, and five concerned the Observation Fire Post subtask. The CATs for the audio CASs consisted of a prerecording of the voice of the experimenter and were played once over the VE surround sound system at a

consistent volume. These same words were presented in the text condition and during the AAR in response to the identical first errors.

The sensory attributes for the text CAS consisted of Times font, black on white background, and appeared in the foreground center bottom of the field of view. There was a maximum of five lines and 218 characters in a trapezoidal arrangement (in order to ensure visibility in the head mounted display) in a rectangular text box which overlaid the VE images for twelve seconds (arbitrarily set through user testing). An example of the text CAS is shown in Figure 4 above.

The *provide cue combinations* instructional tactic was implemented by the arrow lines being presented first followed immediately by the audio coaching or text coaching CAS.

In terms of the *timing* CAT, all CASs were presented when the experimenter clicked on the labeled button representing that directive on the experimenter's control monitor (see Figure 8) upon commission of the first error in each subtask phase.

During the mission, participants in the control condition could only receive administrative directives, delivered orally. They received the same AAR feedback as the intervention groups.

After exiting the VE, the participant completed another SSQ (monitoring for any debilitating effects of VE exposure), and an AAR of approximately five minutes duration was provided. During the AAR the same feedback messages which were presented during the mission were examined. That is, the 5-10 second mission segment containing the error was replayed and then,

in accordance with (Bailey, 1982) and Army training doctrine, the participant was prompted to: (a) state what the error was; (b) why it occurred, and; (c) what could be done to correct it. Each of the three mission segments contained one AAR feedback message. If no error was made during a phase, a segment was shown and their actions were affirmed. Members of the control group received no feedback messages *during* the mission, but experienced the same AAR feedback process afterwards.

Each participant proceeded through four map and VE missions during the experiment, with the scenarios being presented in counter-balanced order. The counter-balancing scheme presented each of the two modeled environments non-sequentially, each with two different starting points. This counter-balancing produced eight unique sequences, which formed the basis for the minimal number of participants in each of the six conditions, with two opposite sequences repeated. For all participants, the fourth mission was the no-intervention test mission. No AAR was administered after the test mission. After the VE training and the first and last mission the participant completed a Presence Questionnaire. The participant was then debriefed and kept onsite for at least 20 minutes after the final mission, and given a delayed SSQ at the end of the 20 minutes to ensure that there were no lingering effects from the VE experience.

Outcome Measurement Procedure

The VE system recorded events every second. Total mission time recording began when the participant was told to begin the mission and recording ended when the participant indicated that he was finished, or the experimenter enforced the twelve minute time limit. Because there was

inevitable lag time at both the beginning and end of every session, performance time was measured from the time of first mark (usually a BO mark) until the time of the last mark made (almost always an OFP mark). Data reduction software routines were used to automatically determine subtask time intervals based upon the marks made.

Task performance was generated by rating the correct application of appropriate rules for the different aspects of each subtask. Bounding Overwatch positions were scored based on the summed and averaged ratings for spacing distance, cover and concealment, and overlapping fields of fire from the previous marked position. Helicopter Landing Zone positions were scored on the summed and averaged ratings for clearance from obstacles, proximity to village center, and the correctness of size and shape. Observation Fire Post positions were scored on the summed and averaged ratings for observation clarity, cover and concealment, and landing zone coverage. Three Experimenter/Subject Matter Experts (SMEs) independently scored each mission by reviewing common digital snapshots of critical mission events from the AAR file and recording their point ratings on a Microsoft Excel spreadsheet (Figure 9).

	BO Total Score					
	11.2500					
Landing Zone						
1. Clearance (m above/below)		30+	21-30	11-20	1-10	0
Length (100 meters)	4					
Width (50 meters)	2					
	Clearance Average					
	3.0000					
2. Proximity to Village Center		> Circle 4	Circle 4	Circle 3	Circle 2	Circle 1
From LZ mid point	1					
	Center Proximity					
	1.0000					
3. Size and Shape		0	1	2	3	4
Dist. b/t top marks (14)	4					
Dist. from top to mid (14)	2					
Dist. from mid to bottom (7)	4					
Top horizontal w/ base	3					
	Size Average					
	3.2500					
	LZ Total Score					
	7.2500					
Observation Fire Posts						
1. Clear Approach Observation		0%	25%	50%	75%	100%
OFP 1	3					

Figure 9. A portion of the SME scoring spreadsheet

Inter-rater reliability (α) for the ratings on the test (fourth) mission subtasks averaged .89, which was deemed acceptable.

The effectiveness outcome was the averaged task performance score for each subtask. Time-efficiency was calculated by dividing the subtask performance score by the subtask time (in seconds) which yielded a points/second efficiency measure.

CHAPTER FOUR: FINDINGS

Two complementary analytical approaches - inferential statistics and decision analysis - were used to analyze the effects of CASs in the instructional environment.

Inferential Statistics Approach

Data Screening

Prior to analysis, effectiveness and efficiency measures for the test mission subtasks were examined through various SPSS programs for accuracy of data entry, missing values, and fit between their distributions and the assumptions of multivariate analysis. One response could not be scored and was replaced with the mean of its experimental group Tabachnick & Fidell (2001). To reduce extreme skewness and kurtosis, data were reflected, transformed, and outliers adjusted according to the following procedures as recommended in Tabachnick & Fidell (2001). First, the negatively-skewed effectiveness measures for the three subtasks were reflected (each value was subtracted from the maximum value plus one) in order to obtain positive skewness. To obtain greater normality for the six outcome measures, four measures were logarithmically transformed and two were square root transformed. In order to reduce the confounding impact of outliers while retaining the greatest amount of information, outlying values (defined as more than 1.5 standard deviations from the group mean) were adjusted, rather than deleted, by changing them to one interval less than, or greater than, the next closest value. For example, a case with an outlier value of .161 for BO efficiency was adjusted downward to a value of .132, as the next

highest score in the distribution was .131. Using this technique, the BO effectiveness measure required no adjustments, BO efficiency required five, LZ effectiveness required two, LZ efficiency required two, OFP effectiveness required one, and OFP efficiency required five adjustments.

Statistical Analysis

After screening the data, a 2 x 3 between-subjects multivariate analysis of variance (MANOVA) was performed on six dependent variables: BO effectiveness, BO efficiency, LZ effectiveness, LZ efficiency, OFP effectiveness, and OFP efficiency. Independent variables were the six content augmentation strategies: no strategy, arrow, audio coaching, text coaching, arrow + audio coaching, and arrow + text coaching.

SPSS MANOVA found no significant main effects, although there was a near-significant main effect for arrow for the OFP efficiency measure, $F(1, 54) = 3.89$, $p = .054$. In planned pairwise comparisons there were two significant findings. Audio coaching was significantly different from text for the LZ effectiveness measure at a level of .045, and audio coaching was significantly different from no strategy for the LZ efficiency measure at a level of .042. As audio coaching is the factor that is consistent between these comparisons, audio coaching would appear to have an effect on performance. To investigate these relationships further, planned comparison t-tests for unequal groups were then conducted, at the risk of increased probability of Type II error. Because this research was exploratory and design-oriented, rather than explanatory, hypotheses were tested at the .05 and .10 levels of significance (Goldiez, 2004).

Hypothesis One: Participants receiving any content augmentation strategy will outperform controls. A significant difference was found for LZ efficiency ($t(58) = 1.971, p=.027$) for those receiving any strategy compared to the control group which did not receive a strategy. More specifically, significant differences for LZ efficiency were found for those receiving the audio strategy ($t(18) = 2.444, p=.013$) and the arrow + audio strategy ($t(18) = 2.752, p=.007$) compared to those in the control group. Significant differences for LZ effectiveness were found for those receiving the arrow strategy ($t(18) = -2.206, p=.021$), the audio strategy ($t(18) = -1.623, p=.061$), and the arrow + audio strategy ($t(18) = -1.378, p=.093$) compared to those in the control group. Figures 10-12 and Tables 2-4 characterize these comparisons. Note that for effectiveness measures the lower score is better due to data reflection.

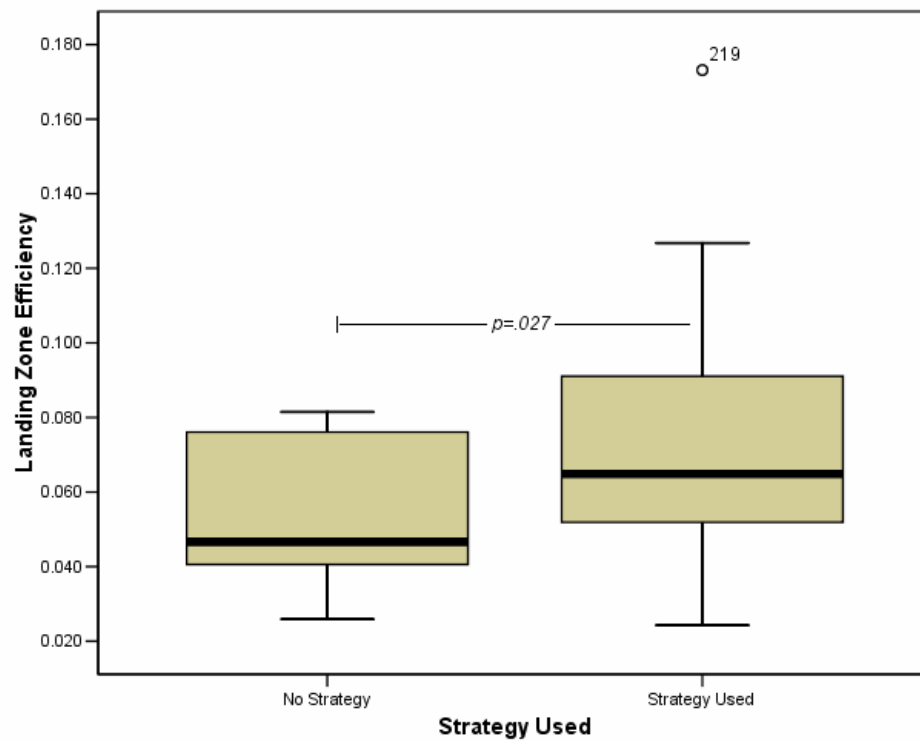


Figure 10. Boxplot of Hypothesis 1 (H1) LZ efficiency overall comparison

Table 2. H1 LZ efficiency overall comparison

Efficiency	Mean	Std. Dev.	Sample Size
Strategy Used	.071	.028	50
No Strategy	.052	.019	10

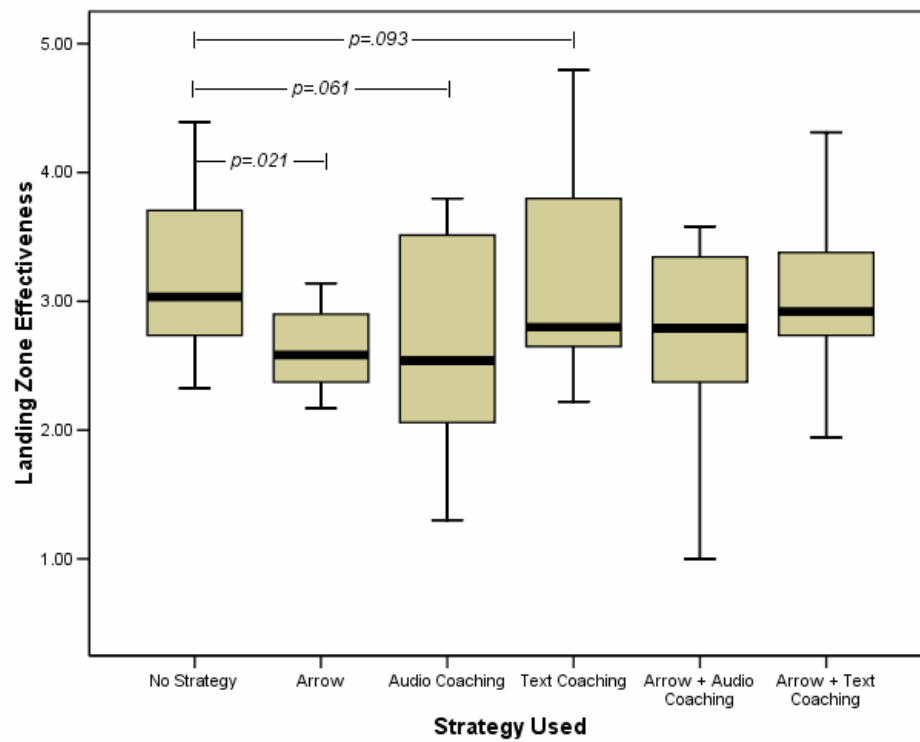


Figure 11. Boxplot of H1 LZ effectiveness individual comparisons

Table 3. H1 LZ effectiveness individual comparisons

Effectiveness	Mean	Std. Dev.	Sample Size
Arrow	2.64	.346	10
Audio coaching	2.61	.830	10
Arrow + Audio coaching	2.70	.807	10
No Strategy	3.15	.646	10

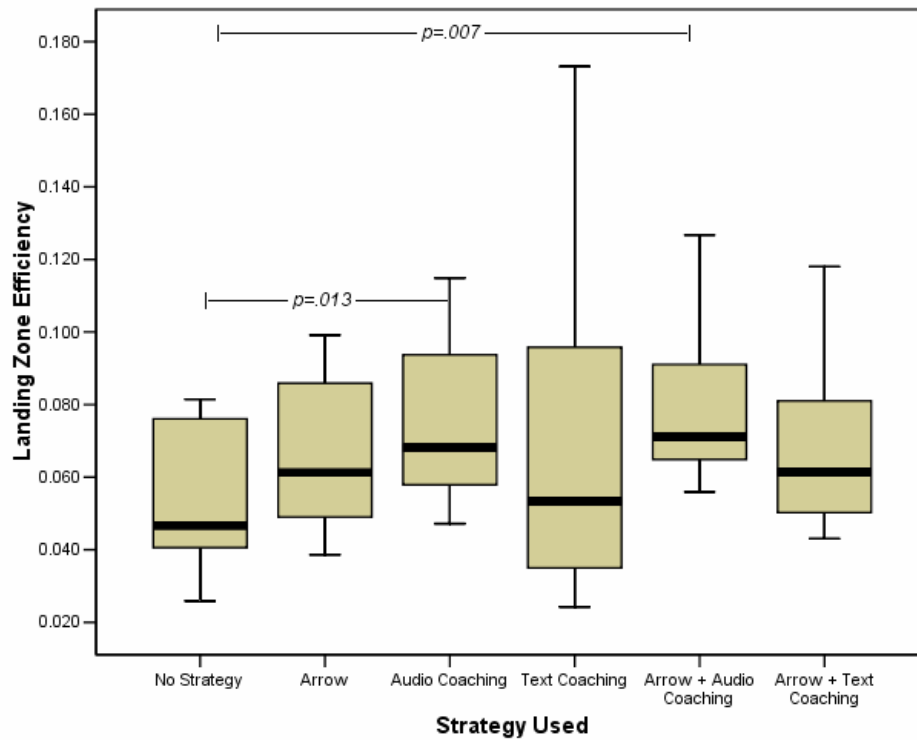


Figure 12. Boxplot of H1 LZ efficiency individual comparisons

Table 4. H1 LZ efficiency individual comparisons

Efficiency	Mean	Std. Dev.	Sample Size
Audio coaching	.076	.023	10
Arrow + Audio coaching	.078	.021	10
No Strategy	.052	.019	10

Hypothesis Two: For single content augmentation strategy conditions, participants receiving audio coaching will outperform participants receiving text or arrow content augmentation strategy. Significant differences were found for LZ effectiveness ($t(18) = -1.560$, $p=.068$) and

OFP efficiency ($t(18) = 1.504, p=.075$) for those receiving the audio strategy compared to those receiving the text strategy. Significant differences were also found for BO efficiency ($t(18) = 1.449, p=.082$) and OFP efficiency ($t(11.715) = 1.656, p=.062$) for those receiving the audio strategy compared to those receiving the arrow strategy. Figures 13-15 and Tables 5-7 characterize these comparisons.

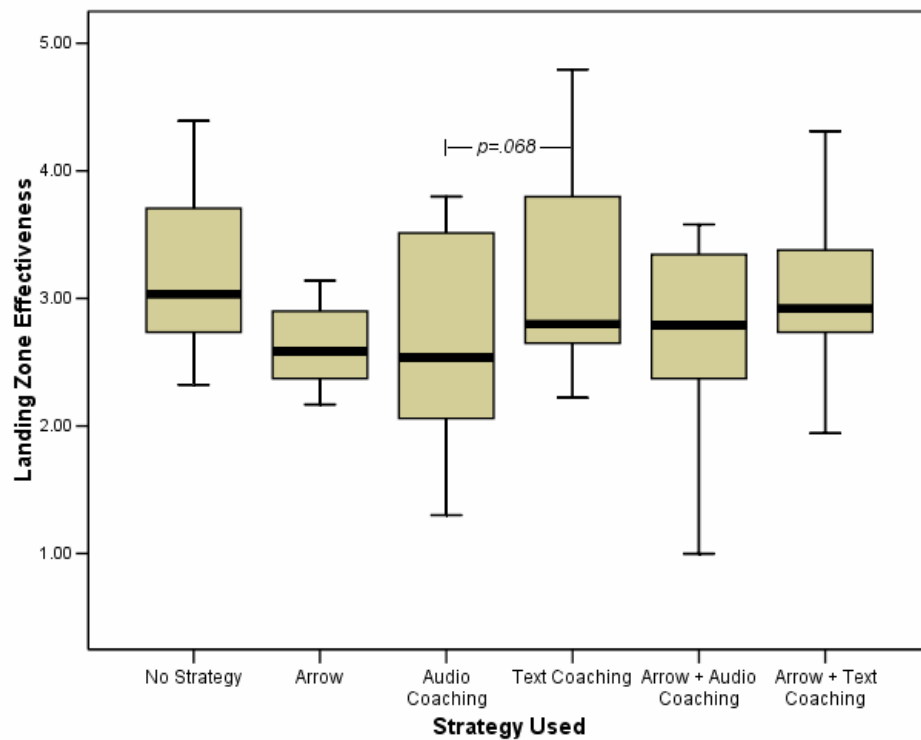


Figure 13. Boxplot of H2 LZ effectiveness individual comparisons

Table 5. H2 LZ effectiveness individual comparison

Effectiveness	Mean	Std. Dev.	Sample Size
Audio coaching	2.61	.830	10
Text coaching	3.18	.796	10

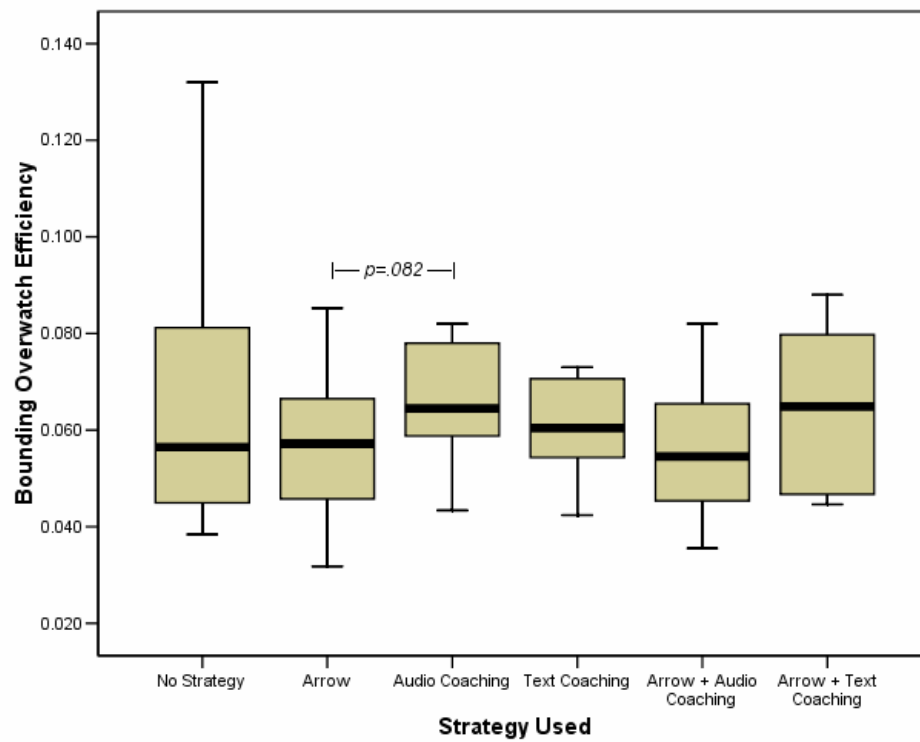


Figure 14. Boxplot of H2 BO efficiency individual comparisons

Table 6. H2 BO efficiency individual comparisons

Efficiency	Mean	Std. Dev.	Sample Size
Audio coaching	.066	.012	10
Arrow	.056	.016	10

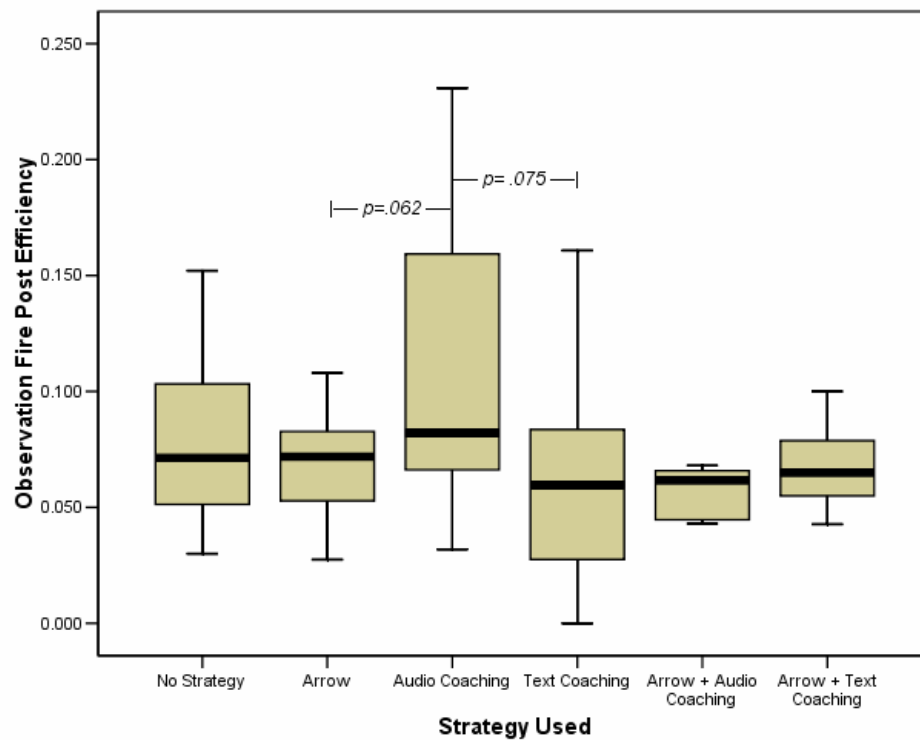


Figure 15. Boxplot of H2 OFP efficiency individual comparisons

Table 7. H2 OFP efficiency individual comparisons

Efficiency	Mean	Std. Dev.	Sample Size
Audio coaching	.106	.063	10
Arrow	.071	.025	10
Text coaching	.067	.051	10

Hypothesis Three: For single content augmentation strategy conditions, participants receiving text coaching strategy will outperform participants receiving arrow content augmentation strategy. No significant differences were found.

Hypothesis Four: Participants receiving multiple content augmentation strategies will outperform participants receiving a single content augmentation strategy. No significant differences were found.

Table 8 summarizes the results of the t-tests for the statistical analysis.

Table 8. Summary of significant p values for the planned comparison t-tests

Hypothesis	Bounding Overwatch		Landing Zone		Observation Fire Post	
	Effect.	Effic.	Effect.	Effic.	Effect.	Effic.
1. Any outperforms controls				.027		
Arrow – No strategy			.021			
Audio – No strategy			.061	.013		
Arrow + audio – No strategy			.093	.007		
2. Audio outperforms text or arrow						
Audio – Text			.068			.075
Audio – Arrow		.082				.062
3. Text outperforms arrow						
4. Multiples outperform singles						

Decision Analysis Approach

Although not the focus of this research, developing an analytical approach to complement the existing intuitive approach to instructional design decision making may result in better instructional design decisions and better learner performance than using the statistical approach alone. As Winn expressed it (1993, p.119), “The most important role for psychological research and theory in [instructional] message design is to furnish analytical tools, not to provide cut-and-dried recipes for design”. Further, only through considering general principles found in the perception and cognition research literature can designers “cultivate an understanding of the processes by means of which people learn.....There is simply no other way message designers can learn their business, or that message design can be done”. Indirectly, true to Naturalistic

Decision Making theory (Klein, 2003), Winn is recognizing the need for both analysis and intuition in making instructional design decisions.

Sorting through the constellation of alternatives available in generating the optimal learning environment is a daunting task. These instructional design decisions are hard decisions in that they are complex, deal with uncertainty, have multiple conflicting objectives, and have multiple perspectives. Mollaghasemi and Pet-Edwards (1997) discussed multiple criteria decision analysis methods such as multiattribute attribute utility theory (MAUT) for comparing alternatives across several criteria, and may be a tool useful to instructional designers. In the present experiment there were two outcomes (attributes), effectiveness and efficiency. MAUT, aided by simulation for uncertainty management, may be an appropriate decision analysis method for the analyzing the experimental data.

MAUT can be used when the following summarized and experimentally-applied assumptions for expected utility are met (Clemen & Reilly, 2001)(Clemen, 2001):

1. Ordering and transitivity – the decision maker (DM) must be able to articulate logically ordered outcome preferences. Here, the trainer DM could articulate preferences between effectiveness and efficiency using ratios through the weighting factor.
2. Reduction of compound uncertain events – reducing complex events would not affect the DM's preferences. The one CAS decision required is a simple one. There is no need for reduction, so this assumption is met.

3. Continuity – a reference gamble can be constructed with some probability for which the DM will be indifferent. Because the trainer DM should seek to make the best strategy decision for the learner, and not the trainer, this assumption is met.
4. Substitutability – events of equal value can be substituted for each other. Only two simple outcomes are of interest here, so this assumption is met.
5. Monotonicity – the DM prefers the reference gamble with the higher probability of winning the preferred outcome. As the outcomes are trainer determined, the probability of using the recommendation is certain, so this assumption is met.
6. Invariance – payoffs alone always determine decisions. The CAS with the highest expected utility (i.e., payoff) will constitute the recommendation.
7. Finiteness – no consequences are considered infinitely bad or infinitely good. The trainer should recognize that using the recommended CAS never guarantees goal success, only a higher probability of success based upon what is currently known. This assumption is met.
8. Mutual preferential independence – one attribute is preferentially independent of another if preferences for specific outcomes of one do not depend on the outcome level of the other attribute. The CAS preference ratios are determined by the trainer through the weighting factor and are assumed constant.
9. Utility independence - one attribute is preferentially independent of another if preferences for uncertain values of one do not depend on the level of the other attribute. In this analysis, a risk neutral CAS utility function was assumed, so this assumption is met.

An automated decision analysis tool was sought which could conduct the DA analysis on the CAS data. The Palisades Software DecisionTools Suite (Industrial Edition), a commercially-available add-in to MS Excel, was chosen to implement this simulation-aided MAUT approach to optimal CAS determination. The different modules of the suite perform the necessary DA steps.

The DA approach taken for the three subtasks was an approach similar to military course of action analysis (Falzon, Zang, and Davies, 2000) or system configuration design alternatives (Law & Kelton, 2000). The approach is detailed in Appendix J and summarized here.

First, in order to have a basis of comparison with the qualitatively and quantitatively different outcomes measures (effectiveness in points and efficiency in points/second), z scores were calculated. Second, the subtask decision trees were constructed in the PrecisionTree module. Third, the @Risk module was used to model the uncertainty necessary to build a requisite decision model. Fourth, the RiskOptimizer module was used to optimize the risk neutral additive utility function (Equation 1) by stochastically simulating the underlying uncertainty model.

$$U(x_1, \dots, x_m) = \sum_{i=1}^m k_i U_i(x_i) \quad (1)$$

Here,

$$U(\text{Effectiveness, Time Efficiency}) = k_E U(\text{Effectiveness}) + k_I U(\text{Time Efficiency}) \quad (2)$$

Once the expected utility values of the CAS branches had been determined through the modeling and simulation of the uncertainty in the subtask measures, PrecisionTree marked the winner of the competition for each subtask by marking that branch with “TRUE” and the others with “FALSE” (see Figures 16-18 for the LZ CAS exemplar).

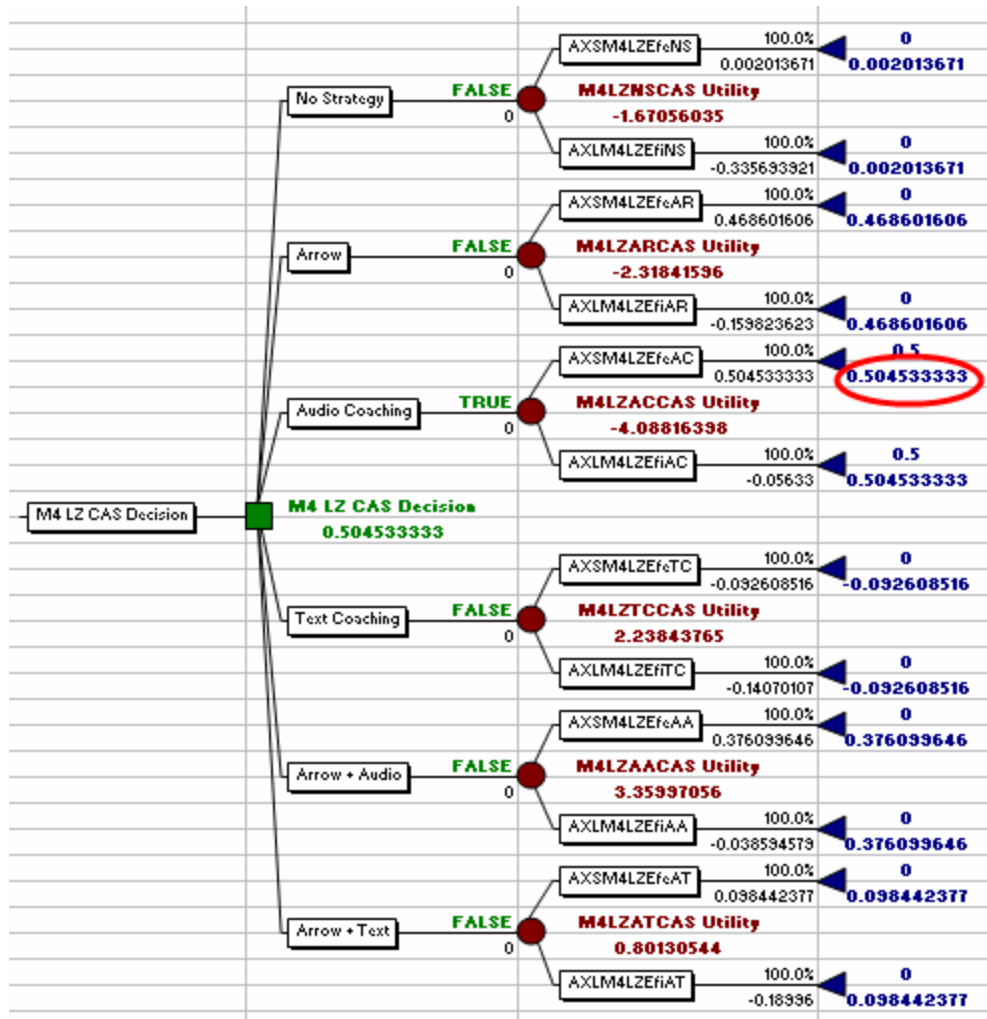


Figure 16. LZ CAS decision after optimization simulation with $k_E = 1.0$. Note the highest end node expected utility value which determined audio coaching as the CAS winner.

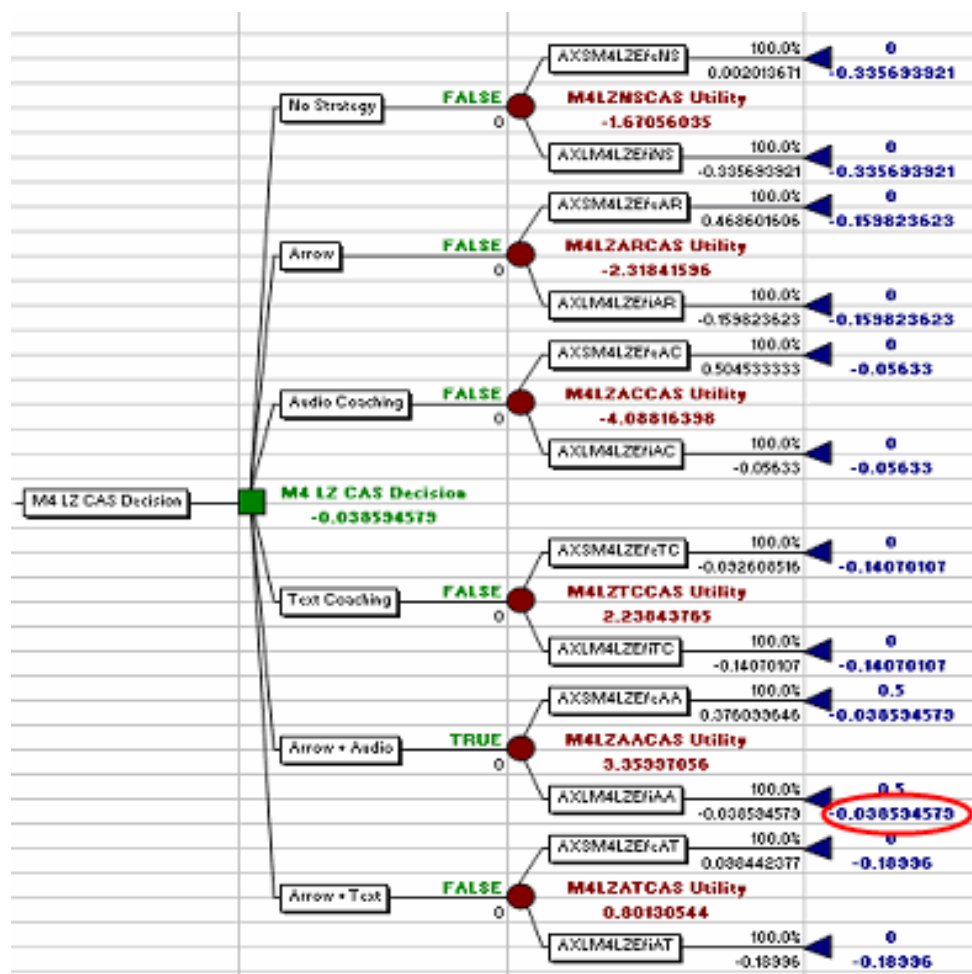


Figure 17. LZ CAS decision after updating of optimization simulation with $k_I = 1.0$.

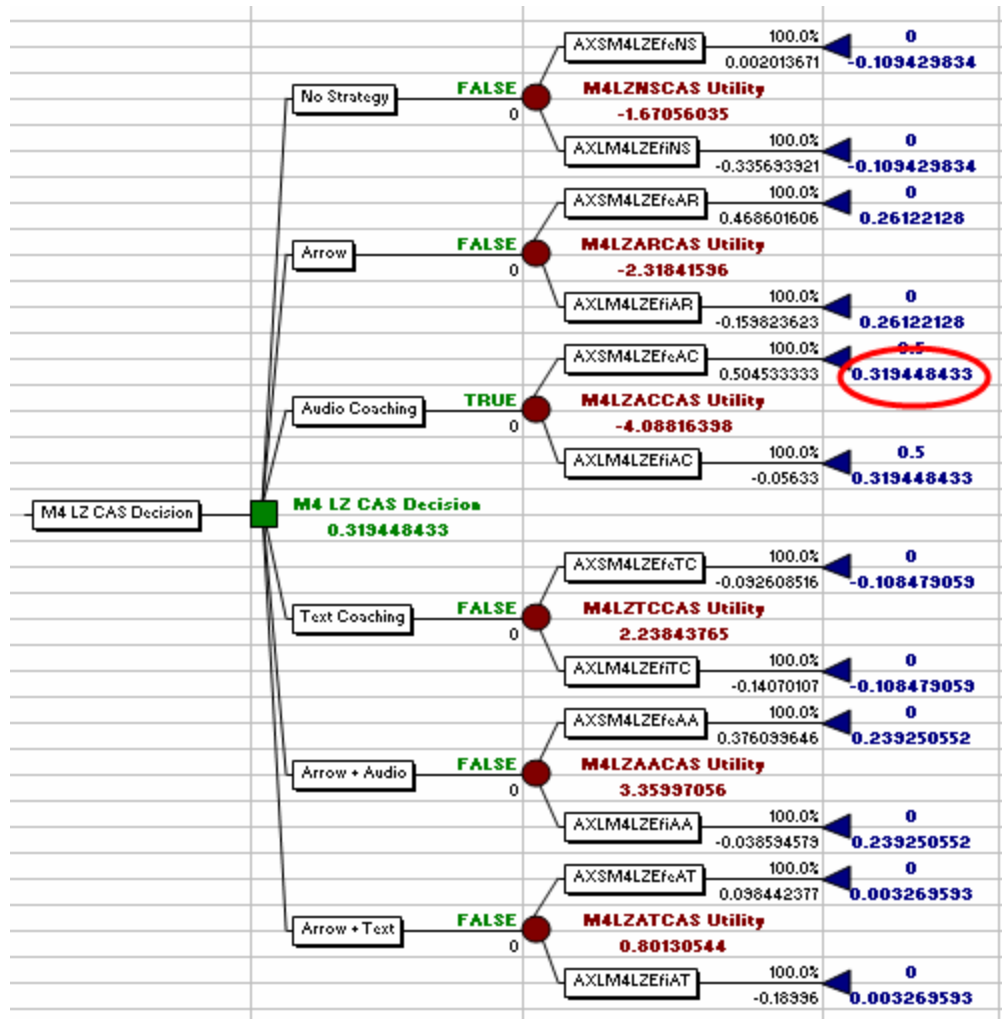


Figure 18. LZ CAS decision after recalculating utility with arbitrary $k_E = .67$ and $k_I = .33$

This procedure was used identically for all three subtasks. It must be noted that a “brute force” method was used with these simulations in the interest of being as correct as possible by maximizing variability at the expense of finesse. That is, normal procedures in simulation construction such as sensitivity analysis, variable reduction techniques, and genetic algorithm fine tuning were not conducted.

It is also important to recognize that the simulation model has not been validated. However, one statistician (L. Malone, personal communication, November 1, 2005) has compared the DA approach to the statistical approach this way:

Most people incorrectly try to use parametric tests on rating data ...created to evaluate instructional design. Many times, whether using this incorrect approach or using nonparametric statistics, one is unable to show statistical differences at the traditional .05 level of significance. This is most likely due to the small sample sizes and/or the variability of the data. The [DA] approach taken ... is unique and mathematically correct. While quantifying the evaluation ... the data [is used] as weights in a decision analysis approach to picking the best design. This has two distinct advantages, namely it provides an objective, numerical approach to evaluating instructional design and is mathematically valid.

Therefore, assuming model validity, Table 9 summarizes the results of the CAS decisions for the subtasks for effectiveness only ($k_E = 1.0$), efficiency only ($k_I = 1.0$), and an arbitrary multiattribute utility scenario where the trainer considers effectiveness twice as important as efficiency ($k_E = .67$, $k_I = .33$). The ability to easily conduct such tradeoff analyses is an advantage of the DA approach.

Table 9. Training guideline recommendations from the DA approach

Training Guidelines	Bounding Overwatch		Landing Zone		Observation Fire Post	
	Effect.	Effic.	Effect.	Effic.	Effect.	Effic.
DA Simulation ($k(E \text{ or } I) = 1.0$)	Audio	Audio	Audio	Arrow + audio	Audio	Audio
DA Simulation ($k_E = .67, k_I = .33$)	Audio		Audio		Audio	

CHAPTER FIVE: CONCLUSIONS

The goals of this research were to: (1) strengthen the conceptual framework surrounding content augmentation strategies; (2) replicate and extend a previous content augmentation strategy experiment, and; (3) if possible, derive general training guidelines for the use of these strategies. These goals were met. First, the OSS Layers Model provides a more logical and comprehensive instructional design framework for studying content augmentation strategies than the previous experiment and is instantiated in this research. Second, the previous CAS experiment was successfully replicated and extended. The third goal is addressed below.

Discussion

Table 10 summarizes the results of the two analyses of the experiment and the training system guideline recommendations which flow logically from the analyses.

Table 10. Summary of the significant effects (p values) of content augmentation strategies with consequent training guideline recommendations

	Bounding Overwatch		Landing Zone		Observation Fire Post		Hypothesis Interpretation	
Hypothesis	Effect.	Effic.	Effect.	Effic.	Effect.	Effic.	($\alpha = .05$)	($\alpha = .10$)
1. Any outperforms controls				.027			Supported	
Arrow – No strategy			.021					
Audio – No strategy			.061	.013				
Arrow + audio – No strategy			.093	.007				
2. Audio outperforms text or arrow								
Audio – Text			.068			.075	Not supported	Supported
Audio – Arrow		.082				.062	Not supported	Supported
3. Text outperforms arrow							Not supported	Not supported
4. Multiples outperform singles							Not supported	Not supported
Training Guidelines								
Inferential Statistics ($\alpha = .05$)	None	None	Arrow	Arrow + audio	None	None		
Inferential Statistics ($\alpha = .10$)	None	Audio	Arrow	Arrow + audio	None	Audio		
DA Simulation (k_E or $k_I = 1.0$)	Audio	Audio	Audio	Arrow + audio	Audio	Audio		
DA Simulation ($k_E = .67$, $k_I = .33$)	Audio		Audio		Audio			

Several patterns emerge from examining these data:

1. CASs may significantly affect learner performance.
2. CAS effects appear to be task dependent. Here, they clearly seemed to have the greatest effect on the LZ subtask, then the OFP subtask, then the BO subtask. Arguably, the subtasks can be ranked similarly in terms of difficulty.
3. CASs seem to improve efficiency more than effectiveness. This implies an influence on time to perform a task.
4. The audio strategy appeared to be the most beneficial single strategy.
5. The arrow strategy which significantly benefited LZ effectiveness seemed to interact with the significant beneficial effects of the audio strategy for LZ efficiency to produce a strong significant effect for the arrow + audio LZ efficiency measure.
6. The level of trainer risk in accepting the probability of committing a Type I error (α) is a factor in determining the recommendations using the statistical approach. Both the BO and OFP efficiency recommendations changed from none at .05 to audio coaching at .10.
7. The DA approach results compare favorably with, and may be superior to, the statistical approach results. As Clark (1983) points out, discovering what works is different than determining why it works. Whereas the cognitive scientist may be concerned with *why* certain stimuli impact learning performance, the instructional designer needs only to know *which* strategy is optimal. The rigorous cognitive scientist, under the Hippocratic caution of “first, do no harm”, might be comfortable making only those recommendations at the .05 level of significance and possibly miss helpful training recommendations. The instructional designer, using the definition of

the OSS, would be comfortable recommending that CAS which represents the highest probability of goal success under constraint. The designer might be especially confident in this experimental case where the performance results of a control “No strategy” group are known and inferior. Although the trainer may not know why, using the DA approach may result in better performance.

Although this research was exploratory and design oriented, attempting to explain the results, although challenging, may be useful for future research.

First, the greater number of significant results compared to the previous experiment may be due to better procedural discipline such as recorded coaching messages and time limit enforcement, but it may also be due to the form of the coaching/feedback. Romiszowski concluded “In general, [knowledge of performance] feedback is more effective when it transmits more complete information.” (Romiszowski, 1993). This may explain why the clear and extensive “Here is your error, here’s what you should have done, do it again” directive feedback (e.g., “There is an obstacle within the Landing Zone. A Landing Zone requires a clear 100x50 meter area. Move the Landing Zone.”) appeared to get better results than the more ambiguous and simpler interrogative feedback (e.g., “Does this LZ provide the appropriate clearance?”) from the previous experiment.

Second, the spread of significant interactions amongst the subtasks may be explained by cognitive load theory. Boldovici (1992, p.7) posited that “adaptive (salience altering) techniques will be effective only with tasks that are difficult to learn”. Careful examination of the

Participant's Training Manual (Appendix B), error messages (Figure 7), and scoring criteria (Figure 9) reveal an interesting pattern. For the BO subtask, there were arguably three primary rules trained, three CAS feedback messages about the rules available to the experimenter and three criteria scored; respectively seven, seven, and eight for the LZ subtask, and; three, five, and three for the OFP subtask. As shown in Table 10, there was one significant interaction for the BO subtask, seven for the LZ subtask, and two for the OFP subtask. Thus, the number of significant interactions is approximately proportional to the number of rules required to be learned and recalled, subsequently reinforced, and scored. It could be argued, therefore, that the LZ task was the most complex and difficult, followed by the OFP subtask, then the BO, and that the learner benefited from the CASs proportionately. Apparently, the greater the cognitive load required, the greater the benefit from the CAS. This supports Boldovici's hypothesis. Further, the LZ task may have benefited much more than the others because the number of rules required to recall and apply was much greater, and may even have approached or exceeded working memory capacity.

It may be that other geospatial soldier tasks from the Jacobs et al. (1994) study can be similarly analyzed for the number of rules required for successful learning and application. For those tasks that can be trained in VEs, the ones requiring the greatest number of doctrinal rules may be the best candidates for CAS use. For example, learning observational route planning, field artillery calls-for-fire, and intelligence gathering scouting missions may be aided significantly by CASs, depending on their difficulty as measured by the number of rules required to recall and apply. Further task analysis research on these tasks is recommended.

Third, the general dominance of the audio strategy could be explained by same channel sensory overload. “When the eyes are actively in use tracking some naturally-occurring action feedback, it is better to avoid the introduction of other visually perceived feedback. A bell or buzzer may be used to alert the learner of some off-target condition without drawing attention away from the principle control activities of the task” (Romiszowski, 1993). Likewise, Bailey (1982, p.326) concluded, “Speech may be preferred when the message calls for immediate action, vision is already overburdened, or the job requires the user to move about continually.” These were characteristics of all the geospatial subtasks and so the audio strategy may have further burdened the visual channel the least.

Training System Recommendations

In summary, for instructional VE systems designed for similar guided learning situations - tasks, learners, time constraints, and disregarding economic constraints - the following recommendations are made:

- The ability to implement the audio and arrow content augmentation strategies, individually and simultaneously, should be required in virtual environment training systems.
- These content augmentation strategies should be implementable by level of acceptable trainer risk, task, and outcome measure.
- Until the promising decision analysis approach has been properly validated, the following CAS training guidelines from the statistical analysis should be used:

1. IF the level of acceptable trainer risk (probability these data are due to chance)
 $\leq .05$ THEN
 - A. IF the task approximates landing zone emplacement AND the measure is effectiveness, THEN implement the arrow content augmentation strategy
 - B. IF the task approximates landing zone emplacement AND the measure is efficiency, THEN implement the arrow + audio content augmentation strategy
 - C. ELSE do not implement a content augmentation strategy
2. IF the level of acceptable trainer risk $\leq .10$ THEN
 - A. IF the task approximates bounding overwatch position emplacement AND the measure is efficiency, THEN implement the audio content augmentation strategy
 - B. IF the task approximates landing zone emplacement AND the measure is effectiveness, THEN implement the arrow content augmentation strategy
 - C. IF the task approximates landing zone emplacement AND the measure is efficiency, THEN implement the arrow + audio content augmentation strategy
 - D. IF the task approximates observation fire post emplacement AND the measure is efficiency, THEN implement the audio content augmentation strategy
 - E. ELSE do not implement a content augmentation strategy.

- This line of research should continue.

Recommendations for Future Research

Experimental Recommendations

The methodological changes from the previous experiment (e.g., increased number of participants, 1 experimenter rather than 2, recorded coaching, more precise arrow, etc.) seemed to benefit the present experiment (i.e., produced more significant effects). Additional improvements for future experimental research should be considered:

1. The arrow shape needs to wider at the base in order to mitigate confusion about which end constituted “convergence” on the error source. Several participants followed the wrong end of the arrow in the early missions.
2. Consider using a simultaneous “audio + text” CAS for “between-channel redundancy” (Winn, 1993), although the literature is mixed on this intervention. For example, Hannafin (1993, p. 193) concluded, “Dual coding is ineffective when both sources of information employ identical coding mechanisms. Identical presentation of words in sound and text, for example, should be avoided.”
3. Consider using multiple raters for all missions, not just the test mission. Learning curves over time could be generated and further insights revealed.
4. Less structured tasks should be investigated.

A Framework for Future Research

The OLM framework introduced in Chapter One is itself framed and expanded in this section.

A Unified Framework for Guided Learning

Guiding the learning of others is an old and noble human activity. The foundational premise behind such efforts is that artificial guided learning is better than naturally occurring trial-and-error learning. By “better” we usually mean learning that is more effective, more efficient, with better retention, transfer, and appeal. However, “Most environments are not structured to promote appropriate interactions which will efficiently and effectively engage the learner’s fundamental learning mechanisms. Instruction is the science and technology of determining how to ‘design’ effective learning environments” (Merrill, 2002). We look to the expertise of educators and trainers to obtain these outcomes from learners through this rational process of instructional design and its implementation in optimal learning environments. Yet Reeves (2000) notes that “Decades of ...instructional ...research ...have provided an insufficient foundation of theory and principles to guide practice, especially in K-12 schools, higher education, business training, or any other learning context.” Even though guided learning is the second largest industry in the United States and the resultant knowledge a key factor in an individual’s income (Greenspan, 2004) and quality of life, a strong analytical foundation for the logic of guided learning, and hence the design of optimal learning environments, has yet to be constructed. The result is suboptimal learning environments and unfulfilled learner potential.

One goal of this paper is to conceptually strengthen the study of CASs by comprehensively situating the effects of content augmentation strategies in instructional virtual environments within a unified logical framework. Framing is selecting “some aspects of a perceived reality” to enhance their salience “in such a way as to “promote a particular problem definition, causal interpretation, moral evaluation and/or treatment recommendation.” (Entman, 1993) Frames can help process vast amounts of information by selecting and prioritizing, they help audiences “locate, perceive, identify, and label” the flow of information around them (Goffman, 1974). For learning theories, frameworks are bold, general sets of constructs that define the important aspects of cognition. They are insufficiently specified to enable predictions to be derived from them, and are descriptive in nature. In the spirit of learning theory frameworks, the following key constructs comprising this guided learning problem definition are proposed:

1. There are two kinds of learning: naturally-occurring trial-and-error learning and artificial, human-contrived, intentional, guided learning. Other terms expressing the idea of guided learning are education, training, mentoring, tutoring, computer assisted instruction, and many others. For this paper, the entities that conduct these activities, and/or the design of these activities, are referred to as learning guides.
2. All learning is environmentally mediated. For the purposes of this paper, the environment is defined as that which generates sensory stimuli. Therefore, instructional systems researchers strive to identify “the extent to which various arrangements and characteristics of stimuli promote learning” (Boldovici, 1992). Environmental mediation of learning may be necessary until technology advances to the point where we can, say, swallow a knowledge pill or directly download knowledge from a computer into the learner.

3. The over-arching goal of the entire guided learning enterprise is the generation of the optimal stimulus set for learning goals (OSS_L). That is, all subgoals, resources, concepts and methodologies directly or indirectly serve this goal. The OSS_L is the optimization of the sum total of all sensation contained in the (conscious, for this paper) sensory channels operating under the real-world constraints of any guided learning situation. The concept implicitly assumes that there really is “one best way” to conduct education and training in any situation – that there is only one solution “out there”, waiting to be discovered. Because generating the OSS_L is the best learning guides can do, it is what they should strive to do. As one educator expressed this idea more generally, “No matter what professional position we may hold...we all have the same goals when it comes to the education of the students we serve. We want to create optimal environments for learning.” (Christison, 1997)
4. Except for fully automated learning environments, OSS_L determination should always be a combination of intuition and analysis. According to Naturalistic Decision Making (NDM) theory (Klein, 2003), when people make decisions from information, “Intuition and analysis/metrics are not conflicting and incompatible forces. Neither is sufficient—both are necessary. Our job is to find ways to synthesize both of them in order to transcend each one.” In other words, building a stronger analytical foundation to complement the existing intuitive approach to instructional design should result in higher quality instructional design decisions. Expressed mathematically:

$$OSS_L = \text{intuitive component } (OSS_I) + \text{analytic component } (OSS_A) \quad (3)$$

A Unified Field Theory of Guided Learning

Frameworks can be elaborated, by the addition of assumptions, to make them into theories that can then generate predictions. In physics, the unified field theory is:

the long-sought means of tying together all known phenomena to explain the nature and behavior of all matter and energy in existence. In physics, a field refers to an area under the influence of some force, such as gravity or electricity, for example. A unified field theory would reconcile seemingly incompatible aspects of various field theories to create a single comprehensive set of equations. Such a theory could potentially unlock all the secrets of nature and make a myriad of wonders possible, including such benefits as time travel and an inexhaustible source of clean energy, among many others (Saviour, 2005).

Likewise, a valid unified field theory of guided learning should subsume all other theories related to the guided learning phenomenon. Like the unified field theory of physics, guided learning researchers should seek to create a single comprehensive set of equations for descriptive purposes. They can then use those equations to answer important questions, such as predicting the outcomes of various instructional interventions. Perhaps then it may be possible to “potentially unlock all the secrets” of guided learning.

Unlike the theoretical descriptive unified field theory of physics which will always be true, however, any prescriptive unified field theory of guided learning equations may only be

situationally true. It is unlikely that prescriptive guided learning will discover “laws” or equations that will be optimal in every situation. For example, the knowledge base from which prescriptions will be made should be constantly changing as knowledge about learning and instructional design accumulates. Variable values within learner models, goal models, and resource models will change over time as well. So too will methodologies which will use existing knowledge to determine the OSS_L . The OSS_L process should yield the optimal solution for that situation, and the likelihood of ever having identical situations, assuming reasonably complex models, will be small indeed.

There have been discussions about the need for such a unified field theory (Duchastel, 1998). However, a candidate has apparently not emerged. First Principles of Instructional (Merrill, 2002) appear to prescribe a superset of principles from the scores of instructional design theories and models extant (Ryder, 2005) and may be the closest existing idea to the unified field theory of guided learning concept.

Principle 1-Problem-centered: Learning is promoted when learners are engaged in solving real-world problems.

Principle 2-Activation: Learning is promoted when relevant previous experience is activated.

Principle 3-Demonstration (Show me): Learning is promoted when the instruction demonstrates what is to be learned rather than merely telling information about what is to be learned.

Principle 4-Application (Let me): Learning is promoted when learners are required to use their new knowledge or skill to solve problems.

Principle 5-Integration: Learning is promoted when learners are encouraged to integrate (transfer) the new knowledge or skill into their everyday life.

However, these proposed principles, while probably true, are based upon the experienced intuitive synthesis of one recognized expert in the field and have no direct mathematical foundation. What is needed is visible, inspectable, analytical knowledge to complement this tacit, intuitive knowledge.

Inherent in the guided learning principles of the unified framework is that there is one best way (ties can be broken through lotteries) to conduct guided learning. At its scientific best, the analytic component of instructional design decision making (OSS_A) is always a mathematical function of the guided learning situation as shown in Equation 4.

$$OSS_A = f(\text{guided learning situation}) \quad (4)$$

A model is a set of assumptions which usually takes the form of mathematical or logical relationships (Law & Kelton, 2000). Although an omniscient deity would completely understand how things work, models of phenomena are the best humans can do. Therefore, in order to obtain the minimal guided learning outcomes of effectiveness (learner model performance/goal model), efficiency (effectiveness/time model or effectiveness/economic model), retention (effectiveness/extended time model), transfer (effectiveness/new goal model), and appeal (learner model affective measure), I argue the assumptions of a learner model, a goal model, an economic model, and a time model will always be required. These forces are always influencing

instructional design in any guided learning situation, even if not explicitly modeled. Therefore, a minimal “model of models” for any guided learning situation is the Unified Field Theory of Guided Learning:

$$\text{OSS}_L \text{ model} = \text{OSS}_I + f(\text{learner model, goal model, time model, economic model}) \quad (5)$$

An instructional designer can make each constituent model as simple or complex as necessary for the problem being addressed. For example, within the learner model would reside a learning theory submodel within which a working memory sub- submodel would reside. A good comprehensive instructional design theory will always explicitly recognize the influence of these forces on instructional design decisions and, at its most precise, the result of the intersection of these influences will be mathematically expressed.

The OSS Layers Model (OLM)

The OSS_L model is determined and implemented through implicit (OSS_I) and/or explicit (OSS_A) instructional design models. Although there are scores of instructional design theories for various pieces of the unified framework and unified field theory posited above, there appears to be no instructional design theory which comprehensively addresses these omnipresent forces and none which has a mathematical foundation. Therefore, one must be constructed.

The OSS Layers Model (OLM) introduced earlier is proposed as an instructional design model that meets these requirements and has the characteristics of an instructional design theory

(Reigeluth, 1999; see Chapter One above). According to this model, the instructional designer must make analytically optimal design decisions with regard to the following logical layers in the following sequence:

Layer 1. Learning environment (also a physical layer). The learning environment is defined as that which generates sensory stimuli for learning goals. Examples include the classroom, virtual reality, and augmented reality. Learning environments afford the generation of content objects, their employment through instructional strategies, instructional tactics, and all other lower levels of the model. In addition to deliberate content stimuli, the learning environment may generate other necessary but content-irrelevant stimuli. Examples here may include *ambient temperature, ambient lighting, and pressure from the encumbering VE apparatus.*

Layer 2. Content object(s) (also physical). A content object is a learning resource which serves as the vehicle for transmitting knowledge from one human to another. Examples are a book or an instructional computer program, and when meeting certain standards, can be electronically shared (e.g., Advanced Distributed Learning (2004)).

Layer 3. Content instructional strategies. Instructional strategies “represent a set of decisions that result in a plan, method, or series of activities aimed at obtaining a specific goal” (Jonassen & Grabowski, 1993). Highlighting the importance of instructional strategies, Hannafin (1993, p.193) concludes, “Effective instruction, independent of particular media, is based upon the selection and organization of instructional strategies.... Capability [of the learning environment] defines what can be, but pedagogy defines how best to utilize capabilities.” The proper knowledge and use of instructional

strategies enables guides to “work smart” with content objects. Examples include *enable learner elaborations* and *provide cueing systems*.

Layer 4. Content instructional tactics. Instructional tactics “represent specific actions which are well-rehearsed and are used to enable the [instructional] strategy” (Jonassen & Grabowski, 1993). Examples include *provide prototypical examples* and *provide graphic cues*.

Layer 5. Content augmentation strategies (CAS). These are plans, methods, or series of activities aimed at implementing instructional tactics, and is the layer of interest in this paper.

Layer 6. Content augmentation tactics (CAT). These tactics determine how the CASs will be executed. CATs are necessary because the CASs can be implemented in different ways which may change the cognitive experience. For example, text “communicates a great deal of information by its appearance on the page or screen that is independent from the information conveyed in the words.” (Winn, 1993). Other examples may include the *control source, timing, location, and duration* of the CAS stimuli.

Layer 7. Content augmentation object(s) sensory attributes (also physical). Content augmentation objects can be thought of as stimuli overlaying content objects. Every content augmentation object has sensory attributes. For example, when using text to generate instructional messages, “The variables that the message designer has to work with are type size, style, and...color.” (Winn, 1993). The reason for the text strategy type style used in the experiment is because “Black type on white background is optimal” (Winn, 1993). Other examples include the stimulus characteristics of the arrow or audio content objects implemented through the CASs.

Layer 8. Learning strategies recommendations (also physical). Learning strategies are the “information processing methods that people use to control their learning, which can involve processes of attending/perceiving, encoding, and retrieval” (Tessmer and Jonassen, 1988, p.34). Making these recommendations to the learner represents the learning guide taking the learner the “last inch” to the watering hole. The guide cannot drink for the learner – do the hard work required for learning - but can recommend how to drink optimally for the situation at hand. Knowledge and use of learning strategies enables the learner to “work smart” and may result in better outcomes. Examples of learning strategies include *create an acronym* and *outline* a book chapter.

According to the OLM, the OSS_A would consist of the combined physical stimulus layers which would persist, at its most technologically demanding, no less than 55 milliseconds – the outer limit of human conscious sensation (Csikszentmihalyi, 1990). Faster stimulus generation may be possible, but why go to the expense when the stimuli cannot be sensed, let alone perceived? Guiding the learning of others through environmental optimization could be thought of as generating these 55 millisecond optimal stimulus set chunks.

Instantiating the OSS Layers Model

If the OLM is valid, it could be implemented by any sufficiently-specified and stimulus-controlled guided learning empirical study. In this case the theory was instantiated through the present additionally-purposed empirical study investigating the effects of various content augmentation strategies in teaching a military helicopter landing zone scouting task in an

instructional VE. Immersive VEs systems and stationary-background augmented reality (AR) systems have an advantage over other study environments in that every stimulus *can* be controlled and recorded and therefore is a promising environment for OLM instantiation. The present experiment addresses one layer of the prototype OLM theory - the content augmentation strategies layer - and it is this layer which is varied while all other lower and upper decision layer variables are kept constant. Figure 19 shows the complete instantiation of the OLM model (refer to Figure 2 above) for the CAS experiment where $k_1 = 1.0$. The logical layers in white and the physical layers in grey constitute the complete instructional prescription. The sum of the physical layers constitutes the optimal learning environment instructional signal for this situation. If the same learning environment and procedures were then used to conduct actual training by the same population and the CAS recommendation is accepted by the trainer, then one could argue that at the moment each CAS is implemented through its associated content augmentation object, for at least 55 milliseconds, the OSS_A has been generated, the OLM instantiated, and the Unified Field theory of Guided Learning instantiated.

OSS Layers Model			OSS Solutions (Physical layers = instructional signal)		
Layer	Outcome Weights Table		Bounding Overwatch	Landing Zone	Observation Fire Post
	Effectiveness	Efficiency			
Learning environment			IST Virtual Environment stimuli	IST Virtual Environment stimuli	IST Virtual Environment stimuli
Tactile - temperature			72°F Ambient temperature	72°F Ambient temperature	72°F Ambient temperature
Tactile - pressure			VE equipment pressure	VE equipment pressure	VE equipment pressure
Content object(s)					
Content Object One			IST VE ARI Exp.7.2 interactive scenarios	IST VE ARI Exp.7.2 interactive scenarios	IST VE ARI Exp.7.2 interactive scenarios
Instructional strategy					
One			Enable learner elaborations	Enable learner elaborations	Enable learner elaborations
Two			Provide cueing systems	Provide cueing systems	Provide cueing systems
Instructional tactics			Provide oral cues	Provide cue combinations	Provide oral cues
IS One			Provide interactive images	Provide interactive images	Provide interactive images
IS Two			Provide oral cues	Provide cue combinations	Provide oral cues
Content augmentation strategies	0	1	Audio	Arrow+Audio	Audio
Content augmentation tactics					
Control source			Instructor	Instructor	Instructor
Timing			At phase first error	At phase first error	At phase first error
Location					
Visual location			-	Foreground extending to error source	-
Audio location			Omni-directional	Omni-directional	Omni-directional
Duration					
Visual duration			-	Until viewed within 20° of error source for 2 sec.	-
Audio duration			One time	One time	One time
Content augmentation object sensory attributes					
Visual attributes			-	3 cyan lines converging on error source	-
Audio attributes			Appropriate recorded error message	Appropriate recorded error message	Appropriate recorded error message
Recommended learning strategies			-	-	-

Figure 19. OLM instantiation with the CAS experiment data where $k_1 = 1.0$. Logical layers are in white, physical layers in grey.

Decision Analysis

Instructional design decisions are hard decisions. Hard decisions are those characterized by complexity, uncertainty, multiple conflicting objectives, and multiple perspectives (Clemen & Reilly, 2001). The components of the OSS model, the learner model, the goal model, the economic model, and the time model imply the interaction of hundreds or thousands of variables in instructional design – certainly qualifying it as complex. It is uncertain in that there appear to be no universal “laws” (Merrill’s (2002) First Principles of Instruction notwithstanding) and accurate assessment of any invisible learning state is fraught with uncertainty. There are multiple conflicting objectives in instructional design. Guided learning outcomes consist of effectiveness, efficiency, retention, transfer, and appeal. Working through these tradeoffs is problematic, as a decision that supports one outcome may well diminish another. An analytical, structured approach to instructional design would require that omnipresent conflicting goals under uncertainty be traded-off in a systematic fashion, with all perspectives and considerations included. The process would be well-documented, facilitate clear articulation of criteria, and explicit definition of preferences. Finally, the scores of existing instructional design models, from behaviorism to guided discovery to constructivism, certainly testify to the myriad of perspectives inherent in instructional design decisions.

Decision analysis has been used in guided learning situations before. In higher education, for example, DA techniques such as analytical hierarchy process (AHP) have been applied extensively (Grandzol, 2005). Applications have included funding research support requests,

deciding on sabbatical proposals, assessing performance and allocating rewards or compensation, choosing students for admission, financial aid, scholarships and awards, evaluating faculty candidates, evaluating faculty, university strategic planning, university budgeting, and MBA curriculum design. While DA techniques have informed the *what*-to-teach decisions of curriculum design, there is no known application of DA techniques to inform the *how*-to-teach decisions of instructional design after the curriculum design decisions have been made.

What is needed is a prescriptive analytical approach to help people deal with the hard *how*-to-teach decisions. The decision analysis framework and its tools may give instructional designers a structured, visible, accountable analytical complement to their intuition and result in higher quality guided learning decisions as evidenced through increased learner performance.

“Although decision analysis provides structure and guidance for systematic thinking in difficult situations, it does not claim to recommend an alternative that must be blindly accepted. Indeed, after the hard thinking that decision analysis fosters, there should be no need for blind acceptance; the decision maker should understand the situation thoroughly. Instead of providing solutions, decision analysis is best thought of as simply an information source, providing insight about the situation, uncertainty, objectives, and trade-offs, and possibly yielding a recommended course of action.” (Clemen & Reilly, 2001). Through an analytical process such as decision analysis, intuitive decision making can become informed intuitive decision making. In the end, better decisions should lead to better learning and increased stakeholder satisfaction.

Summary

In summary, with the goal of generating the optimal learning environment around the learner, the conceptual unity of the Unified Framework for Guided Learning, the Unified Field Theory of Guided Learning, and the OSS Layers Model, in combination with the decision analysis approach for determining the OSS_A , may begin to enable a comprehensive and precise instructional prescription down to the stimulus level which is mathematically based. As such, the combination has the potential to complement existing intuition-based instructional design and synergistically lead to higher quality instructional design decisions. From this point forward, instructional design intuitive decision making can become more analytically informed, the standard for instructional design decisions can be raised from “appropriate” to “optimal”, and instruction can rest on a firmer scientific foundation. This, in turn, may lead to greater learner performance and stakeholder satisfaction. Because these ideas may have the potential to change forever the way humans learn for the better, they are worthy of continued refinement, validation, and research.

APPENDIX A: EXPERIMENTER'S PROTOCOL

GENERAL COMMENTS

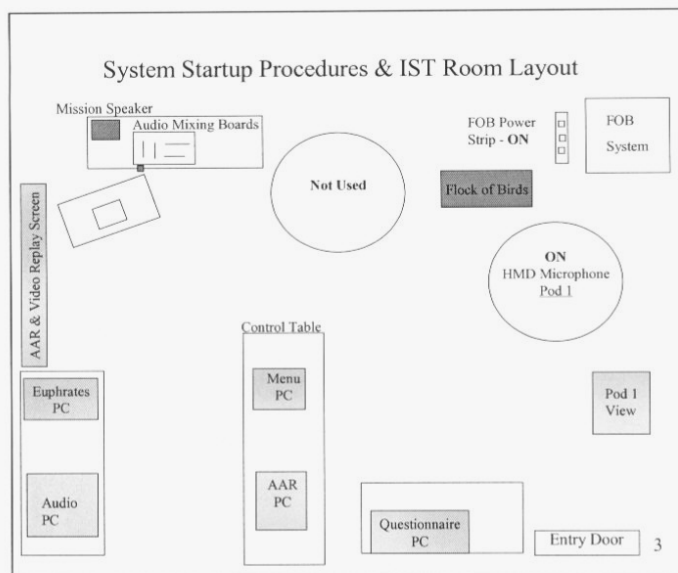
Experiment 7.2 Protocol Overview

1. Phone Interview
2. Start-up Procedures
3. Introduction
 - Demonstration
 - Consent
4. Questionnaires
 - Biographical
 - Immersive Tendencies Questionnaire (ITQ)
 - Simulator Sickness Questionnaire (SSQ)
 - Presence Questionnaire (PQ)
5. Training
 - VE Training
 - Map Training
6. Mission Sessions
 - 1-3 Training Missions
 - Test Mission
7. Debriefing
8. Shut-Down Procedures

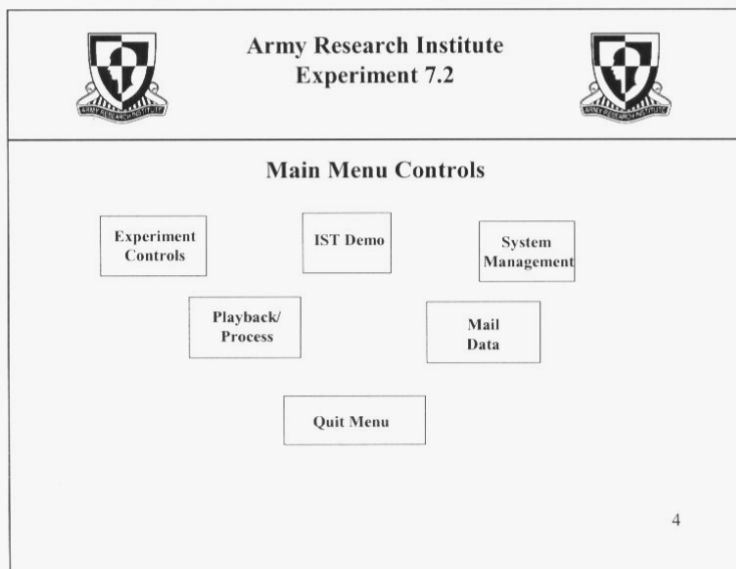
- This Protocol is written as a linear presentation of the course of the experiment. Some of the common windows or functions (e.g., confirmation windows) are introduced or described at the first place where they can occur, and not shown or explained again.
- Information presented in **PLAIN TEXT** is actions the experimenter must take.
- Information presented in *ITALICS* is supplemental experimenter information & guidance.
- Information presented in **BOLD** is read to P.
- Cycle through the experimental sessions consistently.
- Please resist the impulse to improve upon the process.
- Limit VE interaction to 12 min. (once started) within 30 minutes (from initial exposure).
- The time between VE sessions should be kept to a 20 minute minimum.
- Always Train to Consistent Standard.
- Note all exceptions to protocol in P. file on Tracking Sheet.

READ THIS PROTOCOL EVERY TIME !! DON'T PRESUME TO KNOW EVERY WORD!

STARTUP PROCEDURES



1. Turn on menu PC > logon is ari72 – password ariPHONE
2. Menu Logon and all others: username ari - password ariPHONE



1. Menu PC: click on Experiment 7.2 Menu
2. Click on System Management

Supplemental:

Description of Menu PC Main Menu Control Options:

System Management - See next page/slide for taking system off the IST Network and setting up MCO (Multi-Channel Option) for experiment.

Experiment Controls used to start experiment. Described later.

Playback / Process - for processing mission data at end of session.

Process - supports selection of files for processing. Described later.

Playback - used by IST to replay missions for video-taping. Ignore.

IST Demo - ignore

Mail Data - allows selection of files for mailing. Described later.

Quit Menu - ends experiment – see instructions at end of manual

Experiment 7.2

Army Research Institute

System Management Options Panel

MCO Select

MCO on Both

MCO on Pod 1

MCO on Pod 2

MCO on None

Current MCO: both

Network Select

Network On

Network Off

Update

Exit to Options Panel

5

System Management Options Panel

1. Click on MCO on Both - If already selected, leave alone.
2. Click on Network Off to get systems off the IST Network (approx. 5 min. wait: if nothing after 7min., do gacu).
3. While waiting, turn on Questionnaire PC and prepare questionnaires and paper work.

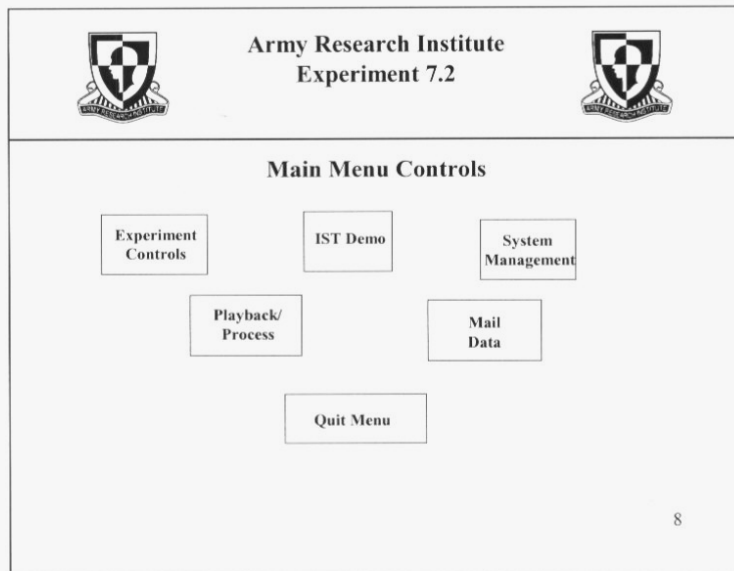
1. Get P# from chart (Experiment Numbers tab)
2. Use:
 1. Experiment Number = 7.2
 2. Group number = experimental condition (1-6); (Experiment Numbers tab)
 3. P. number = ____; (Experiment Numbers tab)
4. Turn on Audio PC (Ensure is ARI 7.2 login)
 1. Click on Connect to ARI data (screen closes)
 2. Click on Shortcut to ARI data
 3. Click on ARI audio capture
5. After MCO on and Network is offline, rubicon comes back up and the Menu PC system management screen reappears) go to hub panel in equipment room & unplug cable from port (small label on wire as ARI 7.2 - #24) on middle panel chest high down in cabinet.
6. Turn on HMD microphone on backpack (small switch on microphone cable)
7. Turn on power strip for FOB - behind black emitter on pedestal.
8. Turn on audio mixing boards (power strip underneath table)
9. Logon to all systems (AAR, rubicon, amazon, yukon) after systems get off network. Same login. If login/password not accepted, reboot PC.
10. Click on Exit to Options Panel if no changes are made - See next page for fixing apparent problems.
11. Turn on Questionnaire PC – prepare questionnaires

Supplemental:

Troubleshooting:



- *If obvious from Stealth View CRTs that MCO is not working, or that update rates are fluctuating, then:*
 1. *Click on update to force systems to check for mode and network status. If things are OK & update selected, nothing will happen. If something is out of whack, then the system will reboot.*
 2. *If dashed lines / fuzziness on either HMD display, then redo MCO mode as follows:*
 1. *Click on MCO on None - wait for screens to clear (30 sec.)*
 2. *Click on MCO on ZORAK - wait for reboot.*

INTRODUCTION



After System Startup, and instructions have been / are being read.

1. Click on Experiment Control to play mission demo.

	Army Research Institute Experiment 7.2 <div style="border: 1px solid black; padding: 2px; display: inline-block;">Start-Up Menu: 7.2</div>	
Experiment Start-up Menu <div style="display: flex; justify-content: center; gap: 20px;"> <input type="radio"/> Training <input type="radio"/> Mission Exercise </div>		
<div style="border: 1px solid black; padding: 2px; margin-bottom: 5px;">Parameters</div> <div style="border: 1px solid black; height: 50px; width: 100%;"></div>	<div style="border: 1px solid black; padding: 2px; display: inline-block;">Start 7.2</div>	<div style="border: 1px solid black; padding: 2px; display: inline-block;">End 7.2</div> <div style="margin-top: 20px;">9</div>

2. Select Training (default) to go to training menus
3. Click on Start 7.2

Supplemental:

Training Startup Menu description:

Start 7.2 - executes selection.

Mission Exercise starts mission Exercise procedures. This is described in the Mission section.

End 7.2 - ends experiment & returns to Main Menu screen.

A verification screen will appear with OK and Cancel buttons after all the exits. OK will return to the Main Menu screen, and Cancel will return to this screen. (Confirmation screens ignored after this notice).

Army Research Institute Experiment 7.2 Training Start-Up Menu		
Participant Number <input style="width: 100px; height: 20px;" type="text"/> Gender <input type="radio"/> Male <input type="radio"/> Female		
<div style="border: 1px solid black; padding: 2px; margin-bottom: 5px;">Parameters: Training Cancel</div> <div style="border: 1px solid black; padding: 2px;"> Gender: Part. Num: Training Mode Task Role Par. Role Ex. </div>	<div style="border: 1px solid black; padding: 2px; display: inline-block;">Start Training</div>	<div style="border: 1px solid black; padding: 2px; display: inline-block;">Exit to 7.2 Start-Up Menu</div> 11


1. Enter P. number (from Experiment Numbers tab) and gender (default = male).
2. Click on Start Training - advances to training control menu

Supplemental:

Cancel - always returns to preceding screen

Exit to 7.2 - returns to Start-Up menu for exit routine.

NOTE: A verification window will appear after the Exit button selection. If exiting, click on OK. This will return to the 7.2 Start-Up menu. Click on the Cancel button to return to this menu. Similar confirmation windows will appear for all "Exit to 7.2 Start-Up Menu" buttons. No further mention will be made of these windows.

 Army Research Institute Experiment 7.2 Training Procedures Control Menu		
Training Mode: <input type="radio"/> Demo <input type="radio"/> VR	Select Training Procedure: <input type="radio"/> Playback Mission <input type="radio"/> Movement <input type="radio"/> Equipment	Completed Training: Playback Mission Movement Equipment
Parameters: Training Cancel Gender: Part. Num: Training Mode Task Role Par. Role Ex.	Start Procedure	Exit to 7.2 Start-Up Menu Pause Experiment 12

1. Before starting, check Audio PC for audio icon
2. Check defaults (Demo & Playback Mission) on Menu PC
3. Click on Start Procedure
4. AAR: click and hold on Select A Preset View arrow button <DemoStart
5. Say:

{Note start time in Excel}

(Start) The Army Research Institute, supported by the UCF Institute for Simulation and Training, has established a Virtual Environment (VE) research program investigating VE technology for training dismounted soldiers. In this experiment, which will last approximately 4.5 hours, you will be trained in a small set of military skills involving map reading, threat assessment, and planning military tasks. A demonstration will be provided in a minute to show you the tasks performed during the exercises. The demonstration is the kind of replay that will be used for reviewing your actual exercises. Our main interest is in how people learn during VE training, particularly cognitive skill development. After training, you will conduct four VE exercises lasting approximately 10 - 12 minutes each. In between VE exercises, you will complete questionnaires, review the preceding exercise, and plan the next exercise. Compensation is \$10.00 per hour of participation, in half hour increments.

Remember that you can withdraw at any time and you will be compensated for your time in the experiment.

Point to VE parts & pieces during the following introduction.

You will stand and walk inside this safety frame while wearing the harness. The visual display in the VE is provided through a position-tracked, helmet-mounted display or HMD. Sensors also provide position tracking for your right arm and hand, body, and feet. After the briefing about the experiment, you will be given training in operations before the experimental sessions begin. Do you have any questions about the VE equipment at this time?

Supplemental: If yes, answer by paraphrasing previous information - Information about the experiment will follow.

6. Use wide screen remote control, press Power On button
7. Have P. watch wide screen and say:

This is a short demonstration of the exercise activities you will be asked to perform later. Before you can do an exercise, you will be trained on all equipment, information, and activities required in the exercise. The demonstration is faster than you might be on your initial exercises, in that the demonstrator is well practiced and has rehearsed this demonstration. Also, the perspective in the VE will be from the ground level, not from above. This kind of replay will be used later for reviewing your actual performance. (Stop)

8. Press Play arrow icon on AAR screen VCR control panel to begin
9. (Check volume controls on mixer board as demo begins (#4 slider))
10. (Use the square Stop button on AAR VCR control panel to stop)
11. Select Preset Views at the indicated time – be vigilant:
 1. @1:10 = Demo1BO
 2. @1:30 = LZLow
 3. @2:20 = LZframed
 4. @3:00 = LZFinal
 5. 3:43 = Ends
 6. Click on Stop button
12. Say:

(Start) **Do you have any problems with participating in this kind of exercise?** [If yes, after demonstration, dismiss with credit / pay.]

Supplemental: Most questions can be answered by asserting that the issue is covered during training which will be provided next. Questions about the VE experiment should be answered by referring to and paraphrasing the experiment introduction and instructions. Remember to portray the experiment as focused on skill improvement, so the P. should always be trying to improve.

13. Turn off wide screen with remote's Power Off button
14. AAR: Select File<Quit
15. Menu: click on Exit Playback
16. Say:

The training and experiment routines will be explained next.

Before we begin the VE training you will complete several questionnaires: The first requests basic biographical information, so that we can describe participants in terms of their age, educational background, prior experience, etc. Next is an assessment of your tendencies toward involvement, addressing how much you get involved in things you do. Another questionnaire is an assessment of your current state of health. This will be repeated during the experiment, in order to monitor your response to the VE experience. The reason we assess your current state of health is because a small % of participants experience simulator sickness. After the VE training, the first VE exercise, and the last VE exercise, you will also complete a Presence Questionnaire, addressing your reaction to each of the VE sessions. Please remember that none of the information gathered will be published in other than group descriptions or analyses. Your data will be coded only with your participant number, the data will be kept separate from your signed waivers, and your information will be kept completely confidential. The training begins with practicing how to walk in our VE. After that you will be trained on the only piece of equipment used, a paint gun. You will also be trained to read maps, and on the rules for tactical movement and landing zone selection. Please remember that even after we start, you can withdraw at any time without prejudice, for any reason. You will be compensated for your time and effort up to that point. Do you have any questions about the experiment? *[Supplemental: Answer any questions by paraphrasing the briefing material.]* **Do you consent to participate?**

17. Give the P. the background information sheet.
18. Have the P. sign the waiver. Review the waiver by paraphrasing text on the waiver forms.

19. Say:

You will take this background information with you.

20. Put P# on tracking sheet

21. Place the signed consent form in the P.'s folder (Stop)

QUESTIONNAIRE ADMINISTRATION

Biographical Questionnaire Instructions

1. Move P. to the Questionnaire PC
2. Ensure the Access Database (ARI 7.2 Questionnaires) is on the screen. Make sure that the folder tab in the window shows Forms
3. Click on Biographical Data - size window full-size
4. Enter 7.2 for experiment number
5. Enter group number (Condition number - from Experiment Numbers tab)
6. Enter P. number (used previously for coding)
7. Say:

(Start) This is a basic biographical information questionnaire. Please use the mouse button next to the PC to select the appropriate response to each question. For some questions, use the mouse to position the cursor and then use the keypad or key board to fill in the blanks. Use the scroll bar to access the rest of the questions. When you reach the bottom of the screen, please notify me. If you have questions, please ask them as soon as they occur to you.

Supplemental: Answer all questions by quoting or paraphrasing prior experiment information. Questions about the biographical questionnaire should be answered as gathering background and experiential information to examine possible relationships with the VE training and experiences.

8. When P. done with questionnaire, click on Save data to Access table (ALWAYS!)
9. Click on Open ITQ (closes form & opens ITQ) (Stop)

ITQ Instructions

1. Enter the P. data for the ITQ.
2. Say ITQ Instructions:

(Start) This is the Immersive Tendencies Questionnaire. Indicate your answer by using the mouse to select the appropriate button on the seven point scale. Please consider the entire scale when making your response, as the intermediate levels may apply. For example, if your response is once or twice, the second box from the left should be marked. If your response is many times but not extremely often, then the sixth (or second box from the right) should be marked. If the question does not

apply to you, mark the leftmost box. All questions must be marked. Use the scroll bar at the right to move down the questionnaire page. When you have finished the first page, use the “Top of the List” button to return to the top of the window, and select the tab for the next numbered set of questions. When finished with all the questions, please notify me. If you have questions, please ask them as soon as they occur to you.

3. Watch the P. to insure that they use the tabs to answer all questions, check the form at the end (ALWAYS!)
4. When P. done with questionnaire, click on Save data to Access table (ALWAYS!)
5. Click on Open SSQ (closes form & opens SSQ) (Stop)

SSQ Instructions

1. Enter the Experiment Number 7.2, Group Number, P. number, and Sequence Number
2. Enter SSQ (& PQ) sequence numbers on Training Record sheet. This sheet is used to track the training sequence, record order & time of questionnaires, and errors made during training.
3. Say SSQ Instructions:
(Start) **This questionnaire investigates your current state of health. This questionnaire will be administered repeatedly during the experiment, before and after each VE session. EACH TIME you should answer based on your CURRENT state of health or physical symptoms. Please indicate how you feel right now in the following areas, by selecting the word that applies. When finished, please stop and tell me you are done. If you have questions, please ask them as soon as they occur to you.**

(Read the following if questioned)

“Fullness of Head” is like a stuffy head cold - full sinuses or sinus pressure (not a runny nose)

“Vertigo” is a disordered state in which the surroundings seem to move

“Stomach awareness” indicates a feeling of discomfort which is just short of nausea.

4. When finished, copy the subscale scores from display windows to corresponding empty data windows
(*Supplemental: Values will not save unless they are entered !!*)
5. Click on Save data to Access table

6. Always record the SSQ sequence number in the P. folder. Software will reject (after the fact) any repeated sequence.
7. Enter the Subscales from the First administration on the tracking sheet. Use the initial SSQ subscale scores in judging P.'s state of health and capacity to continue.
8. Click on Clear form. (*Supplemental: The access program can be left running during the experiment for the repeated administrations of the SSQ.*) (Stop)
9. Go to Training tab

Supplemental:

Data can be inspected by opening the data window in Access database. Use this function to compare scores when P. appears to be sim sick.

1. Use "Window" to switch to database window
2. Click on "database" tab on window
3. Click on SSQ to view current database
4. Inspect by P. number & sequence

When the session is completed, use instructions at end of protocol to backup data & get it entered in ARI database.

SSQ Guidelines

Visual Guidelines for Questioning Participant's Health

Visible pallor, sweating, burping
Apparent dizziness or minor loss of coordination
Sitting with head down & eyes closed during breaks
Lack of communicativeness

Overt illness = dismissal from experimental participation

Vomiting, fainting, falling or staggering
Spontaneous claims or complaints of moderate or severe dizziness, upset stomach, blurred vision or
Other SSQ symptoms

Note: P.s may want to continue when they should quit!

Maximum INITIAL SSQ Total allowed for Participation = 45. See next page for intermediate elevated levels

At post-exposure administration - note scores for elevation over baseline levels. If above baseline, subtract baseline from current score & compare. If remainder is above following values, consider P. to be sick.

Nausea > 33 (if increased by 33)
OculoMotor > 37
Disorientation > 35

Total Severity > 38

If Pre-Exposure levels are also elevated in this range (adjusted for baseline) DO NOT START VE EXPOSURE!

Note: Guidelines are based on 90-95th percentiles from SSQ report. Adjustment from baseline is MJS idea.

When two or more Subscales are elevated over initial values, which should be recorded on the data tracking sheet, extend break until symptoms decrease (if P. wants to continue). Collect an SSQ every 15 minutes during extension. If symptoms do not reduce after 30 minutes - exclude from further participation, keep onsite until symptoms reduce to less than criteria. Recommendations are that the person refrain from vigorous movement activity for at least one day. Walking slowly in a normal visual environment may help.

Onset of serious sickness is often unpredictable. ALWAYS HAVE A CLEAN TRASH CAN HANDY. Clean is recommended, because any smell will set off a nauseous P..

Baseline adjustment logic is as follows. The SSQ is a subjective scale, and some people walk around slightly whatever all the time. By looking at the change in the self-assessed levels we may get closer to a predictive discomfort level. The goal is to keep people from harm, and to enable P.s to continue at their own pace (as long as it doesn't upset the experiment).

Note: Most recover in 20 minutes. If 2 sessions in which P. meets or exceeds changes in levels – dismiss from experiment.

- *Wait 20 minutes (do Debrief)*
- *Administer SSQ again.*
- *If elevated, wait another 20 minutes*
- *Pay for ALL time spent.*
- *Do not release if obviously ill! BE CONSERVATIVE WITH THEIR HEALTH!*

PQ Instructions

1. Administer a PQ after the SSQ
2. Use the Window to get to the Database
3. Click on PQ from the FORM tab list (if necessary)
 1. Enter the Experiment Number 7.2, Group Number, P. number, and Sequence Number (in repeated series)
 2. Use Questionnaire Tracking sheet for questionnaire sequences
4. Say PQ Instructions:
(Start) Please characterize your experience in this environment by selecting the appropriate box of the 7-point scale. Make your responses based on the question content and descriptive labels. Please consider the entire scale when making your

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responses, as the intermediate levels may apply. Answer the questions independently in the order that they appear. Do not skip questions or return to a previous question to change your answer. Please answer all of the questions based on the environment you just experienced. If the question doesn't apply, mark the leftmost box. When finished, please stop and tell me you are done. As always, if you have any questions, you may ask me.

5. Click on [Save data to Access table](#)
6. Use Window to return to DataBase & Click on SSQ. (*Supplemental: The access program can be left running during the experiment.*) (Stop)

TRAINING

Supplemental:

Overview:

1. Start with VE Training immediately after the SSQ
2. After 10 total minutes in VE (from time of 1st HMD use) or when movement training completion - administer SSQ and PQ
3. If VE Training not complete, return to VE after 20 minutes
4. Conduct Map & Military Skills Training
 - a. Introduce Map symbols, contours and visualization
 - b. Review Movement, Posts, and Landing Zone requirements
5. Test Comprehension, Integration, and Performance using test map & multiple choice questions.

The training cycle pattern is intended to keep VE exposures to less than 10 minutes each, and provide a 20 minute break between VE sessions.

Use watch to keep sessions short.

The SSQ data allows tracking of the adaptation process (or non-adaptation & dismissal). Use SSQ tracking sheet.

Administer the PQ after completing VE training.

(Note: always administer the SSQ first.)

Prepare tracking sheet. Put experimenter initials on top right corner.

VE Training

1. Select VR & Equipment (Fort Polk).
2. Click on Start Procedure.
3. Select Paint Gun. (*Supplemental: The load window will appear on the stealth monitor - the stealth display will cover the load window when complete. Have Subject hold HMD off their head until graphics are loaded.)*
4. Click on Start Task.
5. Say:

(Start)The training begins with learning to move in the virtual environment. Each step in training teaches you an important activity or task that will be used later in the planning sessions. Please remember that you can request a break at any time,

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and can terminate the experiment completely whenever you wish, without penalty. You will always be given credit for your accumulated time. Do you have any questions? (Supplemental: Answer based on prebrief and instructions.)

Supplemental:

Overview:

Training Protocol Reminder - Goal is to keep VE exposure down to 12 minutes in any 20. Track time using stopwatch during 20 minute breaks.

Prep tracking Sheet & enter first SSQ numbers.

Select Equipment Training in VE - see next screen.

Do PaintGun and Distance Training in VE next

Then do Map training.

Have them hold the HMD up and look at you during instructions.

Frequently ask the P. how they are feeling. Use SimSick Criteria to call for an enforced break.

If the the session is interrupted by symptoms, administer an SSQ immediately, have P sit quietly for 15 minutes and administer another SSQ. Release only when SSQ returns to near normal (compare to initial SSQ - see instructions).

6. Say:

Please step into the safety pod & we will begin putting on the sensors. Do you have any electrically powered or metal objects in your pockets, like change, a pager or phone, etc? These should be removed to prevent disruption of the magnetic sensor field. (Supplemental: Place anywhere convenient. BEGIN PUTTING ON SENSORS.)

7. Give equipment spiel. - knob adjustment, etc.

8. Say:

First you will learn how to move in our Virtual Environment. The sensors allow the computers to track your motions. You walk by raising one foot higher than the other while standing in place.

Physically demonstrate!

A step should take about a second, keeping your foot raised longer will not give you a longer stride, but stepping more quickly will produce short, fast steps. The system will stop moving at one meter. Hold your foot up until you stop moving to get a full stride. Your steps will always be in the direction your shoulders are pointed, not

where you are looking. While walking always keep your left hand on the railing for safety. Try to stay in the center of the pod!

This is different than movement in the real world. You can't sidestep in the VE, raising a foot will move you forward. You can't jump or run, so please don't try. You should avoid bumping into objects in the VE, you can become "stuck". The easiest way to get free is to turn your body sharply away, or back up.

Physically Demonstrate!

To back up in the VE, carefully slide one foot at least 18" behind the other, without lifting the moving foot off the floor. Move carefully because there may be a handrail support behind you. The training will start on a road with distance markers on each side. Your first task will be to walk to several of the markers, so that you can get used to moving and also become familiar with distance and perspective changes in the system.

Show or point to the hand unit.

There is also a fast movement function that you will practice using. Basically you use the thumb switch on the hand control to get an image of an open hand, point your body in the direction you want to go, and pull the trigger to move. Please don't use that function until you are instructed to do so.

Army Research Institute Experiment 7.2		
Movement Training Control Menu		
Performance <input type="radio"/> Doorways <input type="radio"/> Office		
Data Tracking Correct <input type="text"/> Incorrect <input type="text"/> % Correct <input type="text"/>		
		Trial Number <input type="text"/>
<input type="button" value="Enter Data"/>		<input type="button" value="Clear Last Entry"/>
<div style="border: 1px solid black; padding: 2px; margin-bottom: 5px;">Parameters: Training <input type="button" value="Cancel"/></div> <div style="border: 1px solid black; padding: 2px;"> Gender: Part. Num: Training Mode Task Role Par. Role Ex. </div>	<input type="button" value="Start Trial"/> <input type="button" value="End Trial"/> <div style="display: flex; justify-content: space-around;"> <div> Inter-Trial Time <div style="border: 1px solid black; width: 40px; text-align: center; font-family: monospace;">88:88</div> </div> <div> Reset Trackers <input type="button" value="Reset Trackers"/> </div> <div> VE Time <div style="border: 1px solid black; width: 40px; text-align: center; font-family: monospace;">88:88</div> </div> </div>	<input type="button" value="7.2 Start-Up Menu"/> <input type="button" value="Pause Experiment"/> <input type="button" value="Exit Task"/>

1. Say (when system and P. are ready):

Are you ready to begin? [Get affirmative.]

2. Click on Start Trial

3. Say:

Please put the HMD on now. Make sure the HMD is snug but not too tight. Look around by moving your head slowly, and turning in the pod slowly. Face down the road toward the distance billboards. All of the billboards are approximately the size of a one story house. The numbers are the same height as you are.

Walk to the 0 sign in the middle of the road. Look at the 30 billboard. Hold your foot up until you stop moving to get full stride. Remember you will stop moving at one meter. Count your paces as you move to learn the distance traveled. Start when I tell you to. Now walk to the 30.

4. Provide walking guidance as necessary.

5. Upon arrival:

Look toward the 60 billboard. Use the thumb button on the controller to get to an open hand. Pulling the trigger while the hand is empty will move you in the direction your shoulders are facing. This is called sliding. You can move your shoulders to guide your motion. Please SLIDE to the 60.

Turn and look back to the 0 sign. The slide moves at about 5 meters a second. This can be used to estimate distances without having to walk. Please count seconds and slide back to the 0 sign as directly as possible.

6. Provide guidance re aiming, stopping, and orientation.
7. Watch time/collisions. [Ask how many seconds it took]. Collisions would include running through the billboards or trees. Will get thunk sound. If too slow or clumsy, practice again. If incompetent, dismiss.
8. When finished, say:

Good, please raise the HMD to the top of your head.

9. While HMD is raised, point to the hand controller and say:

The hand unit is also used to control the paint gun that is used for marking positions in the exercises. The thumb button cycles between colors for marking the different sites. The colors are indicated by the color of the hopper on top of the paint gun. The colors include red, yellow, green, and white. The finger trigger (show) activates the paint splats. The middle trigger shoots a big X. White is used for erasing marks when you change your mind about a position. In that case, only the big X has to be erased, you can leave the small splats. The rules for how and when to use the different colors and sprays will be trained later. Your next task will be to make a circle next to you by holding down the trigger to make a series of splats in a circle. Then shoot an X in the center of the circle. I will coach you on the colors and details as we go. This exercise is merely to familiarize you with the equipment. Put the HMD on and we'll begin.

Raise your right hand. (Coach use of thumb button to get gun & first color.)

That is the paint pistol. The aiming line shows you where your marks will end up and the hopper on top shows the color of paint available. Your task is to aim the line where you want the mark to appear, and paint. Please paint a YELLOW circle of splats and then, using the middle trigger, put an X in the center.

Now turn and shift to red and do the same.

Now turn slightly and do a green circle and X.

White is for whitening out mistakes or changes. Please erase the Xs in each circle.

(Supplemental:

- If having difficulty, instruct trainee to hold their elbow close to their body when shooting, this stabilizes the line.
- If paint gun not working – do a GACU.

10. Say:

Good, please remove the HMD.

11. Click on Continue Trial
12. Click on End Trial to stop.
13. Click on Exit task.
14. Click on Exit Equipment to return to the Training Screen.
15. Click on Exit to Startup Menu. (Stop)
16. Help P. out of Pod & harness.
17. (Start) Questionnaire PC: Administer post VE SSQ #2 (Stop)
18. (Start) Administer PQ #1 (go to approx. p.15 for PQ directions) (Stop)

Map Training

1. Give P. the Training Manual notebook. *(Supplemental: the Training Manual is in small black notebook in back area of large drawer under AUDIO PC. Other materials are in top drawer.)*
2. Say:

(Start) This is a training manual that will provide the basic information required to complete the map plans and VE review exercises. Please read all of the material carefully. After you have studied the manual, you will be given a short quiz on the key information presented. You will also practice applying the knowledge by making a practice plan on a map. Once you have demonstrated mastery of the basic knowledge and map skills, the experiment sessions will begin. Ask any questions as soon as they occur to you. Let me know when you are done. Begin.

Map Training & Military Mission Planning

- M/C answers

- | | |
|---------------|-------|
| 1. A | 11. B |
| 2. C | 12. C |
| 3. B | 13. C |
| 4. D | 14. A |
| 5. B | 15. A |
| 6. B | 16. C |
| 7. A | |
| 8. C | |
| 9. D | |
| 10. 14, 14, 7 | |

Grade before giving map.
Provide correct answers – walk through using answers

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- When finished with booklet review (20-45 min.), take booklet back (Stop), (Start) administer quiz on marks, symbols, and rules. Allow 10 minutes for quiz.
- Grade the quiz. If ≤ 3 errors, provide correct answers. If >3 errors, have participant review booklet for general area of items missed & retest. If >3 errors on 2nd test -- wash out of experiment.
(Supplemental: Only allow one review of booklet before dismissing from experiment.) (Stop)
- Retrieve 3 colored pencils & ruler from drawer.
- (Start) Provide map for practice. Read text at top of practice map:
Find an appropriate space for the LZ and plan a path to that area using OCOKA and the movement guidelines to select and mark the BO positions. Lay out the marks for the LZ, and the OFPs that will control access and protect the area. Mark all positions appropriately. Use a dot instead of a circle and an X. Note the scale and start point. Put your first BO position immediately at your start point. You will have 10 minutes. Begin.
- Have P. complete mission exercise as will be done in experiment. (Stop) (Supplemental: Criteria: Reasonable LZ, OFPs, and BO's.)
- (Start) Discuss result. Point out correct answers. (Stop)
- If >3 errors, have P review booklet again and repeat exercise. If even one mistake on 2nd map, dismiss from research.

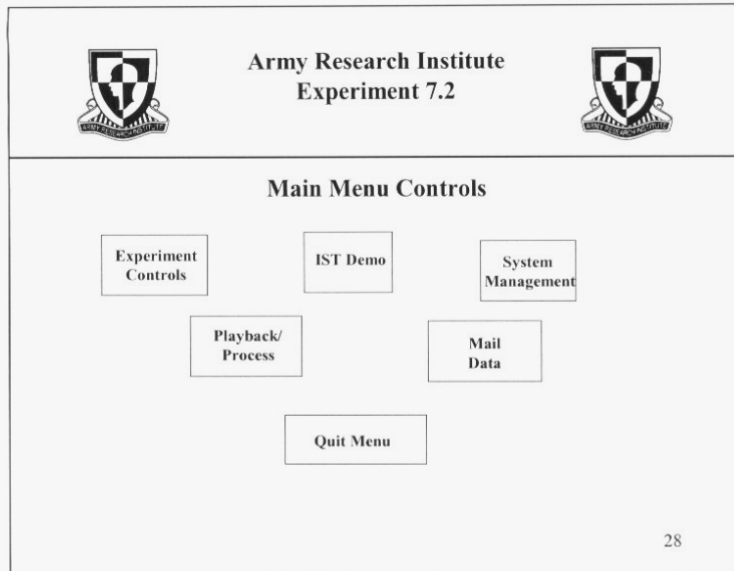
23

MISSIONS

Overview

(Standard sequence goal is 30-35 minute cycle for 4 missions in 2.5 hours)

1. *Start new mission with Map Exercise (start 15 minutes after previous VE exit. Brief constraints and goals.)*
2. *Do Map plan (10 minutes max)*
3. *Administer SSQ (5 min.)*
4. *Start VE & suit-up (5 min.)*
5. *Review mission exercise using their map plan (1 min.)*
6. *Conduct VE exercise (10-12 min.)*
7. *Administer SSQ (and PQ after 1st & last missions)(5 - 10 min.)*
8. *Conduct AAR session (10 min.; do not exceed time; cover one error in each phase each time; repeat twice)*
9. *Cycle back to Step 1*
10. *Last mission:*
 1. *No arrow or coaching, as this is the test mission*
 2. *No AAR after last mission*
 3. *Debrief & payment instead*
 4. *Hold for 20 after post-VE & admin final SSQ*





(Supplemental: After Logon. Wait for connection to tad (watch Pod 1 monitor for logon screen)).

1. For 1st mission: Select Mission Exercise
2. Click on Start 7.2
3. Type in Team Number box: 12 + P#
4. Click on Start Mission Rehearsal
5. Type in P. 1 box: P#
6. Type in P. 2 box: P#
7. Click on Start Mission Rehearsal
8. (If 2d or 3rd mission, click on Return to Mission Rehearsal button)
9. Select scenario – S#
10. (If 2d or 3rd mission, click on Return to Mission Rehearsal button)
11. Say before the first mission, after that they know what is going on:

(Start) To review, before and after each mission you will plan a mission using a map, complete an SSQ, and then review the plan while in a VE representation of the map. Both the map and VE exercises are performed under time constraints. Then we do an After Action Review or AAR of your performance of specific tasks. I will identify critical incidents as they happened in the mission. You will be required to discuss what happened, why it happened, and how to improve. Other than that period, we will not discuss the mission procedures. This enables us to control the AAR interaction and relate that activity to skill development. A Presence

questionnaire (to evaluate your VE experience) will also be administered at the end of the first mission, and again at the end of the last mission.

If at any time during the experiment you experience discomfort, you should remember that you may pause or even terminate your participation at any time. If you experience symptoms that prevent you from comfortably interacting in the VE, you will first be allowed to take a break and recover. You may withdraw at this point if you wish. A second major episode will require that you be withdrawn from the experiment. If you feel lingering discomfort you will be kept onsite until symptoms return to approximately normal, based on the SSQ scores. You will, of course, be compensated for any additional time required in this situation. If necessary, transportation to your residence will be furnished. Are you ready to proceed? (affirmative required) (Stop)

	<p>Army Research Institute Experiment 7.2</p> <p>Start-Up Menu: 7.2</p>	
<p>Experiment Start-up Menu</p> <p><input type="radio"/> Training <input type="radio"/> Mission Exercise</p>		
<p>Parameters</p> <div></div>	<p>Start 7.2</p>	<p>End 7.2</p>

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Map Planning Phase

1. (Start) (After the first mission, at approximately 15 minutes after previous VE mission exit) Provide the appropriate map based on counterbalanced scenario order! (*Supplemental: Keep EXTRANEIOUS comments & discussion to a minimum. 4th Mission is TEST mission = No Arrow, No Coaching*)
2. Say:
Remember that the goal is to plan for movement to an LZ, marking the LZ and the OFPs protecting the LZ. Your start point is there. Plan a Helicopter Landing Zone within the village area, or as close in as possible given the LZ size requirements. Plan the Bounding Overwatch from the start point. Always put a BO immediately at your start point. Mark the LZ and OFPs. Study the map to identify and remember landmarks for navigating in the VE. You will need to remember building size, orientation, and road intersections to navigate in the VE. Note the scale (is different): 1 cm. = 50 m.. You cannot go through green vegetation. You will have 10 minutes. Begin.
3. Stop after 10 minutes of map planning. (Stop)
4. Review without comment and check for completeness.

VE Execution Phase

1. On Menu: Select the proper Scenario using the order scenario order sheet. [Note: Use Scenarios 1-4 (Audio) for Conditions #1 (Control) and #2 (Arrows only)]
2. Select Load Scenario.
3. On AAR: click on Flying/Orbiting button
4. Click on Stealth button
5. Move to appropriate Preset view>
6. Fly down to where the P. is so you can watch P. from behind during mission
7. Administer SSQ
8. Suit up P. in VE (have P. hold HMD)
9. After P. is suited up, show the map again. Allow one minute for study.
10. While P. studying, say:

Note the important landmarks on the map, so that you can navigate to the planned locations. Remember building sizes, orientation, roads and intersections to help you navigate. When you are in the VE, mark the BO positions required to move to the site you identified for the LZ. At the site, if it

fits the requirements, mark the LZ and the OFPs. If the planned area does not meet requirements, find an area that does and mark that area. You may revise the Plan based on the VE conditions.

Supplemental: Keep EXTRANEIOUS comments & discussion to a minimum.

1. (After 1 min. study period)(Start) (For Missions 1, 2 and 3) Say:

The goal is to learn to perform quickly and correctly.

(For Mission 4) Say:

This last mission is our test mission. Please try to perform the exercise as rapidly and accurately as possible.

For Condition #2 (Arrow Only) say:

You might be shown converging lines during the exercise. They are there to help you by pointing out where performance could be improved. Immediately notice where they converge, and consider whether you have done the last few activities correctly. The lines should disappear after about two seconds.

For Condition #3 (Audio Coaching only) say:

You might be given oral messages during the exercise. When you hear the message, act accordingly.

For Condition #4 (Text Coaching) say:

You might be shown text messages during the exercise. When you see the message, read it and act accordingly.

For Condition #5 (Audio Coaching + Arrow) say:

You might be given oral messages during the exercise. When you hear the message, act accordingly. You might be shown converging lines during the exercise. They are there to help you by pointing out where performance could be improved. Immediately notice where they converge, and consider whether you have done the last few activities correctly. The lines should disappear after about two seconds.

For Condition #6 (Text Coaching + Arrow) say:

You might be shown text messages during the exercise. When you see the message, read it and act accordingly. You might be shown converging lines during the exercise. They are there to help you by pointing out where performance could be improved. Immediately notice where they converge, and consider whether you have done the last few activities correctly. The lines should disappear after about two seconds.

2. For All P.s, say:

At the beginning of the session, converging lines will point toward the urban area, to orient you to the terrain. Look to where they converge until they disappear, after about two seconds.

3. On Menu: Select Start Scenario

4. Click on Open Door button

5. Say:

Lower your HMD. Can you hear me OK? (affirmative). Begin the mission.

6. On AAR: Click on Record button

7. IMMEDIATELY Do right ctrl-middle click on a building to insert the orienting converging lines

8. Conduct mission interventions as necessary

Supplemental:

During the mission, track errors using the SCENARIO MAPS.

Mark arrows on maps pointing from P location toward object indicated!.

Condition: COACH OR ARROW BASED ON SCRIPT AND MAP !

If first mission, remind P of thumb switch operation for colors, rapid movement, how to walk, etc. AS NECESSARY.

Use preset views or fly to get around.

Use the timer on the AAR to judge when to shift or stop the mission exercise.

- *CRITICAL INCIDENTS ORDER OF IMPORTANCE:*
 - *focus on VECTORS, Placement, Procedures, Positions, etc.*
- *Route - if route is suboptimal, stop on first error*
- *Overwatch Positions - correct violations of overwatch rules*
- *LZ positioning - make sure space and orientation is adequate*
- *Observation/Fire Post positions - should cover overlapping zones*

Scenarios should come with selectable viewing positions accessible through the view menu.

Viewing positions can be set up by positioning view where desired, and selecting save view on view menu - label with descriptive term.

FLY by holding Shift key and moving mouse - left button forward, right button backs up, center button stops in place.

ARROW - place mouse arrow on object to be viewed.

CONTROL + MIDDLE CLICK & converging lines will be in view until P. gets viewing point in view of HMD

During every mission (including 4th test mission):

1. If still in BO phase, at 5 minutes, click on Admin2 button:
(Audio/Text displayed)
2. If still in LZ phase, at 9 minutes, click on Admin3 button:
(Audio/Text displayed)
3. At 12 minutes, say:
OK, stop and raise the HMD. The planning mission exercise is over.
4. AAR: Click on Stop button
5. Menu: click on End Scenario button (Stop)
6. Unsuit P.
7. Administer SSQ
8. Administer PQ after first and last mission
9. (During Questionnaires, prepare for AAR)

AFTER ACTION REVIEW

AAR Overview

Supplemental:

- *Conduct AAR. The focus is on improving the accuracy of an activity, while maintaining or improving the speed of that activity.*
- *Each AAR should last 10 minutes - use stopwatch for accuracy*
 - *Use RED BUTTON to get split times*
 - *Use ~2&1/2 minutes for each category on Coaching sheet.*
- *Administer extra questionnaires as appropriate!*
- *Conduct next Map Planning Exercise*
- *Administer Recovery SSQ - check for heightened symptoms*
-
- *Review Scenario map & select segments to replay using critical incidents list.*
- *REVIEW IS NON-CRITICAL. Never say "you did this wrong". All requests for guidance should be in terms of the Coaching scripts.*
- *During each Review*
 - *SHOW WHAT HAPPENED - straight replay without corrective comments.*
 - *ASK P. coaching questions*
- *INTENT: Emphasize Procedures and Relevant Stimuli*
 - *IF correct performance, then affirm correct performance*
 - *Urge P to perform faster*

GUIDELINES FOR AAR

- *Bounding Overwatch Position*
 - *1st / most critical error*
- *Same as Map?*
 - *Why / why not*
 - *Major Considerations*
- *What would improve*
 - *Threat vectors*
 - *distance between sites*
 - *support capability*
- *Landing Zone Position Review*
 - *Same as Map Plan*
 - *Why / Why not*
 - *Major Considerations*

- What would improve
 - Threat vectors
 - Helicopter parameters
 - support capability

Use *MODE* menu to select AAR, use video playback buttons to play the Scenario.

If datafile not there, use *FILE* and *LOAD CAPTURED DATA* to load data file. File should be in
vrdata/features/live/tm#es#tl#s#.pdu

See prior note about file error message.

Use the slider bar to move ahead or back.

Use Preset views to observe action - Use Fly mode to augment view when necessary. Use *COACHING GUIDELINES* during AAR

Time should be recorded on *BEHAVIORAL TRACKING SHEET*.

SSQ # should be checked and entered on *BEHAVIORAL TRACKING SHEET*.

Mode

- After Action Review
- Play (2 sec.)
- Pause
- View
- Start

There is no specific instruction for the AAR. The following is an example. Use instructions on next page to find information and select segment for replay.

1. AAR: Click on Playback button
2. Turn on big screen (off during missions)
3. Move P. to big screen
4. Advance to error segment based on Tracking Sheet notation
5. (Start) Say:

The AAR will cover portions of the mission where performance could be improved. Please address what happened, why it happened that way, and what could be done differently to follow the training manual and improve your performance.

6. AAR: Click on Play button
7. Replay AAR segment.

8. Use Pause button between phases; Step ahead button
9. Use the coaching guidelines for the subtask to say appropriate feedback (except "Redo it"). State error again; why do it that way; what can be done to improve, etc. (*Supplemental: There will always be 3 feedback messages for each mission*)
10. Click on Stop button
11. Advance to next error segment based on Tracking Sheet notation
12. Cycle back to Step #8
13. Click on Power Off button on wide screen remote control to turn off
14. AAR: File<Quit
15. Menu: Click on Return to Mission Rehearsal button (Stop)
16. Start next mission (approximately p. 27)
17. After 4th mission: No AAR, conduct debriefing

Supplemental:

Questions should be answered by using the coaching protocols

- *first get them to retrieve information*
- *only on failure to remember correctly do we specify how/what to do.*

AFTER 4th mission - No AAR

Use the coaching sheet to help select a segment and guide discussion.

Goal is to review each activity ONCE on area that can be improved.

This may require being picky or reviewing something that is done correctly but could be improved somewhat.

In ARROW condition, can repeat error from mission.

In coaching conditions, repeat feedback already presented in mission if perception is that P didn't get/understand. Otherwise go to next level for coaching & feedback!

End of Session Procedures Overview

- *Do normal after Mission procedures*
 - *Administer SSQ*
 - *Administer final PQ*
 - *Conduct Debrief*
 - *Provide Compensation*
- *During Recovery Period, Shut Down System*
- *Administer Recovery SSQ at 20 minutes after post VE SSQ*
 - *check for heightened symptoms*

- *Dismiss*

Debriefing

1. Say:

(Start) This experiment examines the effects of skill acquisition and repeated performance on mission planning. At issue is whether there are any differences in skill & performance gains using different instructional techniques. Some participants received coaching, others received an information aiding feature, some received both, and others received no instruction during the exercises. No identified individual data will be published or attributed to any individual participant. Some information about an individual's performance may be used as an example, but would not be identified. All information will be analyzed and reported as aggregate data, for example as averages. We analyze differences in the time, errors, and performance. We also analyze the information from the questionnaires.

The Immersive Tendencies Questionnaire, Biographical data, and Presence Questionnaires investigate the psychological aspects of individual responses to the VE configurations. We are finding that changes in the VE change the responses to the situation.

The Simulator Sickness Questionnaire data is used to track any discomfort from the VE equipment, and adaptation to the situation. Previous research indicates that people do adapt to the VE relatively easily. This research will be used to confirm that finding. Simulator sickness symptoms develop during or soon after exposure to the virtual environment. The symptoms tend to dissipate fairly rapidly with time. It is possible that some residual effect of having been in the virtual environment might be experienced. While this is unlikely, it is possible. If you develop any symptoms like those we have asked you about on the SSQ after you leave or in the next few days, you should sit or lie down and rest until the symptoms go away. It is also very important that we know as soon as possible if any participants experience delayed symptoms. Please contact the Principal Investigator, Dr. Michael Singer at 407 384-3993 if you experience delayed symptoms.

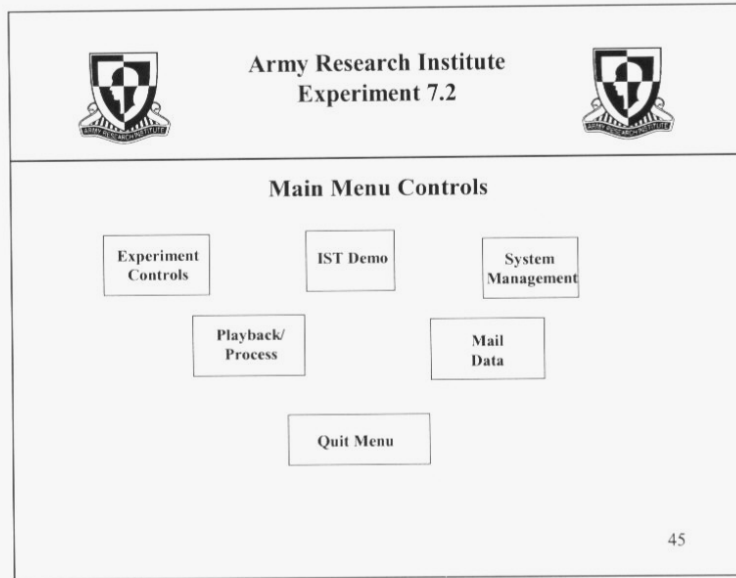
Please remember that in order to get reliable information from research, new participants should not have prior knowledge that would influence their responses to the VE tasks. Please encourage friends and acquaintances to participate in this experiment, but do not tell them details about the experimental task or measures. Remember that participation is voluntary and anyone may withdraw from the experiment at any time without penalty.

You will receive payment or credit for the amount of time that you have participated. Please sign the payment receipt sheet when receiving payment.

2. Provide compensation. (Stop) Ask last SSQ (Note experiment stop time on Excel)
3. Walk them to reception area.

- If arrow, ask "What did the arrow mean to you?"
- Give Psych Dept. Experiment Feedback Form

SHUTDOWN PROCEDURES



1. Click on Exit to Rehearsal Startup
2. Click on Exit to Start-Up Menu
3. Click on End 7.2
4. Click on System Management

Experiment 7.2

Army Research Institute

System Management Options Panel

MCO Select

MCO on both

MCO on Chad

MCO on Tad

MCO on None

Current MCO: both

Network Select

Network ON

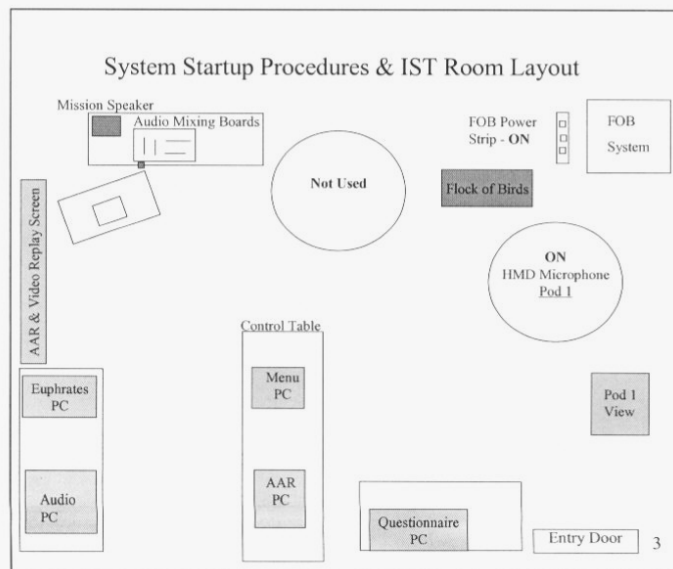
Network OFF

update

Exit to Options Panel

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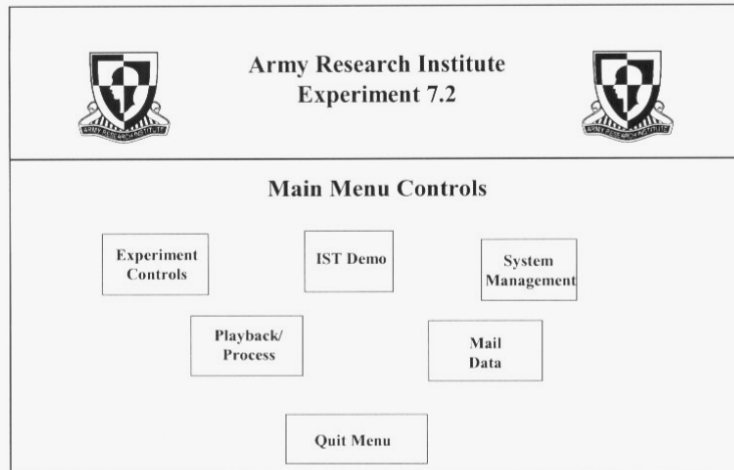
5. Go to hub panel & plug in cable from port #24 (small label on wire as ARI 7.2 - port at bottom right of panel ports) on panel labeled 195.0.
6. Click on Network On to get systems back on the IST Network.
7. Upon return, click on Exit to Options Panel



8. Click on Quit Menu - ends experiment.
9. Turn off CRT for Pod 1
10. Turn off Pod 1 HMD microphone on backpack (small switch on microphone cable)
11. Turn off power strip for Motion Star - behind black emitter.
12. Turn off large sound mixer power strip underneath
13. Audio PC: Close all windows programs at end of day.
14. Right mouse click on ARI Sound on task bar (at bottom right). Select exit to shut down the audio software.
15. Log off Menu, Audio, and Questionnaire PCs.

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POST PROCESSING



47

1. Click on Playback / Process - for processing mission data at end of session.

Supplemental:

Process - supports selection of files for processing. Described next.

Quit Menu - ends experiment

40
38

Experiment 7.2
Army Research Institute

Playback / Post-process Mission Panel

Playback Mission

Post Process File

File #

Post Process All

```

1. tm11000tl100es100s12.ant
2. tm11000tl100es100s11.ant
3. tm11000tl100es100s10.ant
...
...

```

Exit to Options Panel

48

Playback / Post-process - usually done when out of MCO mode and on network. Can be done anytime.

Playback used for replaying complete mission for video-taping.

2. Select number of file to be processed from window. Number should appear in file # window.
3. Click on Post Process File to process file.
4. Click on Post Process All to get all files that appear in window processed.
5. Click on Exit to Options Panel

Experiment 7.2 Army Research Institute

Mail Data Panel

File #

E-Mail Data

name@wherever.com

Post Processed files

1. tm11000tl100es100s12.timeline
2. tm11000tl100es100s11.timeline
3. tm11000tl100es100s10.timeline
- ...

Intermediate Post Processed files

4. tm11000tl100es100s11.sum
5. tm11000tl100es100s10.sum
- ...

Exit to Options Panel

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Select Mail Data from System Management Panel

- USUALLY done when out of MCO mode and on network.

Can be done anytime. Will not mail until back on the net.

Name@wherever.com is where the mail will go. Data should be sent to
mike_singer@stricom.army.mil

- Select number of file to be emailed from window. Number should appear in file # window. Files should appear here after post-processing. If there are no post-processed files available, that message will be displayed in the window.

- Click on **E-Mail Data** button to mail the file.

- EXIT using Exit to Options Panel

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~~40~~

EXPERIMENT NUMBERS

↓ Protocol changes

201	202	203	204	205	206	207	208	209	210
211	212	213	214	215	216	217	218	219	220
221	222	223	224	225	226	227	228	229	230
231	232	233	234	235	236	237	238	239	240
241	242	243	244	245	246	247	248	249	250
251	252	253	254	255	256	257	258	259	260
261	262	263	264	265	266	267	268	269	270
271	272	273	274	275	276	277	278	279	280
281	282	283	284	285	286	287	288	289	290
291	292	293	294	295	296	297	298	299	300

- Determine the P. number from the chart.

Supplemental:

NUMBER IS FIRST USED FOR DEMO - DON'T CHECK OFF UNTIL FORMS ARE SIGNED.

After P. signs waivers, start NEW P. folder for tracking questionnaires and progress.

Select and Check-off P. number as used on next page. System requires a P. number before allowing mission demo.

System will maintain data by P. number during training & mission Exercise.

NOTE: Convention is to use highest numbers for pilot testing and lower numbers for actual data. Strike number off when P. actually agrees to continue. Use the same number with 12 prefix (12XXX) for team number. Data is recorded using the team number.

USE P. NUMBER ONLY TO TRACK EXPERIMENT DATA.

NEVER WRITE P. NUMBER ON WAIVER.

WRITE NAME AND NUMBER ON TRACKING SHEET ONLY!

PLACE INFORMED CONSENT IN TRACKING FOLDER!

Scenario Order Tracking – PILOTS ONLY						
Order	(#1)Control	(#2)Arrow Only	(#3)Coaching- Audio	(#4)Coaching- Text	(#5)Arrow+Coaching- Audio	(#6) Arrow + Coaching- Text
1						
2						
3						
4						
5						

General Correction Routine (GACU)

Use after exiting menu structure & restarting at least once. This routine will shut down and clean up all the systems. Use only if all else fails:

1. Click on rubicon on Menu PC screen.
2. Password: ariPHONE (on all PCs except Menu & Audio)
3. Type: cd offnet/features2/scripts (type: cd onnet/features2/scripts if still on IST network) (use ctrl-H to backspace if necessary)
4. Type: gacu
5. Press ESC on MotionStar Keyboard in corner
6. Type **dosservr** to restart
7. On small black box next to monitor
8. Pull out black power cable
9. Wait 5 sec.
10. Plug back in
11. Menu: Close blank window
12. Minimize rubicon window (in case need to gacu later)
13. Now start everything from menu systems again. (Click on Experiment 7.2 menu icon, etc.

APPENDIX B: PARTICIPANT’S TRAINING MANUAL

INTRODUCTION

As described in the experiment briefing and demonstration, you will complete a series of planning exercises modeled after US Army planning operations in urban (city-like) environments. During each exercise, you will mark a plan on a map and then move through a virtual environment (VE) representing the different towns. The exercise requires marking the location for a helicopter landing zone (LZ), planning movement of a platoon to that LZ, and identifying locations for protecting the landing zone, called observation/fire posts (OFF). In essence, you are planning as if you would lead a platoon to execute the mission of establishing an LZ.

This manual presents the basics of military operations in urban terrain (MOUT) necessary to correctly plan for LZ placement, use a map in planning, and the three types of marks you will use in the exercises. In the first section, movement through MOUT and LZ requirements are explained, including how to mark locations in this research. In the second section, you will learn the basics of how to read military maps, including contour lines and color codes. After training you will be given a multiple choice test on this information. Then you will practice planning movements and marking locations on a terrain map. You must learn and demonstrate the basic information in this manual in order to participate in the experiment.

Military Operations in Urban Terrain

Built-up or urban areas consist mainly of man-made features such as buildings and roads. Buildings provide cover and concealment, limit fields of observation and fire, and block the movement of troops. Streets are usually avenues of approach. However, forces moving along streets are threatened by the buildings and have little space for cover.

Land navigation is important. There are four steps to land navigation. Having an objective and the requirement to move there, you must know where you are, how to plan the route, how to stay on the route, and how to recognize the objective.

Step 1: Know Where You Are. You must know where you are on the map and on the ground at all times and in every possible way. This includes knowing where you are relative to:

- Your orientation
- The direction and distances to your objective(s)
- Other landmarks and features
- Any impassable terrain, the enemy, civilians, and danger areas
- Both the advantages and disadvantages presented by the terrain between you and your objective.

These steps are accomplished by knowing how to read a map, recognize and identify landmarks; determine direction; and measure or estimate distances.

Step 2: Plan the Route. Depending on the length and type of movement to be conducted, several factors should be considered in selecting a good route. These include:

- Time & Distance
- Tactical aspects of terrain (called OCOKA: described below)
- Potential for encountering the enemy
- Availability of good checkpoints or identifying landmarks

The plan must be the result of careful map study and should address the requirements of the mission and time available. It must also provide for ease of movement and navigation.

Step 3: Stay on the Route. In order to know that you are still on the correct route, you must be able to compare and recognize the environmental landmarks (roads, buildings, etc.) you encounter in the VE, as you move according to the plan you developed on the map. There are usually two ways to navigate an environment: dead reckoning (using a compass) or terrain association (recognizing various landmarks from the map in their anticipated positions and sequences as you pass them). Because you will not have a compass in the VE, you must use landmark or terrain association to navigate in these VE exercises.

Step 4: Recognize the Objective. Your objective in these VE missions is locating an LZ for a helicopter. Therefore, recognizing an appropriate location for the LZ is the first step in map planning. You will then need to employ terrain association in order to recognize landmarks that identify the LZ area when the plan is evaluated in the VE exercise.

In MOUT areas, the ranges of observation and fields of fire are reduced by structures. **Targets are usually briefly exposed at ranges of 100 meters or less.** For this reason, *you should evaluate all potential enemy threats within 100 meters of yourself at all times* and make your movement and emplacement plans accordingly.

PHASE 1: BOUNDING OVERWATCH

When moving down a street, the dismounted platoon should move in at least two separate squads, with one squad moving forward while the other squad provides cover. This process of “leap-frogging” ensures safer movement through an urban terrain. Locations where one team should stop while the other moves forward are called *Bounding Overwatch* (BO) positions. Figure 1 provides a diagram of the movement pattern.

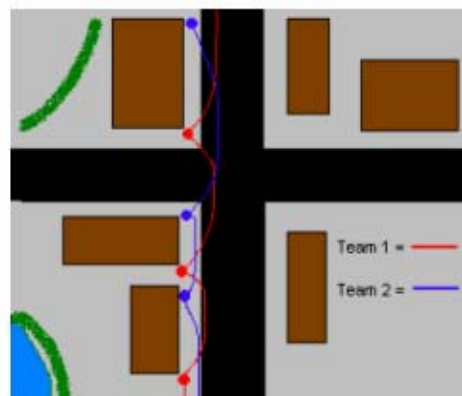


Figure 1. “Leapfrog” Movement

Each BO position should offer cover and concealment for the occupying squad as well as open lines of fire to cover the bounding or next forward moving squad. Example BO positions include the corners of buildings or beside thick brush or trees. *BO positions should not be more than 30 to 50 meters apart*, as a greater separation would not provide the cover necessary for safe movement.

In some cases, you will need to plan for crossing through relatively open areas, such as streets, alleys, and parks. These should be avoided whenever possible as they are natural kill zones. If such movements are necessary, however, take extra precautions to protect the platoon by planning for the most efficient path (i.e., the fastest) between relatively safe areas, such as near buildings. This means selecting *good overwatch positions that cover short distance movements by the bounding squad*. Note that this may mean taking a longer route or setting multiple BO positions to an objective in order to obtain good overwatch or a safer path.

Choosing the best path depends on multiple factors related to the natural surroundings, obstacles, and potential enemy threats. To assist in this process, you should analyze the terrain using the following military-based criteria, referred to by the acronym OCOKA.

- Observation and fields of fire,
- Cover and concealment,
- Obstacles,
- Key terrain
- Avenues of approach.

Observation and Fields of Fire. Observation means seeing the enemy but not being seen. Anything that can be seen can be hit. Therefore, a field of fire is an area that a weapon or a group of weapons can cover effectively with fire from a given position. For purposes of this experiment, *100 meters is set as the operational range for weapons*.

Cover and Concealment. Cover is either natural or artificial shelter or protection from enemy fire. Always try to use covered routes and seek cover for each halt or overwatch position, no matter how brief the halt is.

Concealment is protection from observation or surveillance, including concealment from enemy air observation. When you are moving, concealment is generally secondary to cover; therefore, select routes and positions that protect your teams and minimize the potential for enemy forces detecting or shooting at you. Also, ensure that your squad can place covering fire on potential threats.

Obstacles. Obstacles are any obstructions that stop, delay, or divert movement. Obstacles can be natural (rivers, swamps, cliffs, or mountains) or they may be artificial (barbed wire entanglements, pits, or buildings). Always consider any possible obstacles along your movement route and, if possible, *try to keep obstacles between the enemy and yourself* (see Cover & Concealment above).

Key Terrain. Key terrain is any locality or area that when seized or retained, offers a marked advantage. Within an urban area, *higher buildings may dominate an area*, offering observation and fields of fire. As mentioned before, *narrow areas between buildings may offer cover or may be killing zones* covered by enemy weapons. *Moving through large open areas must also be avoided*. You should always attempt to identify and use key terrain to your advantage.

Avenues of Approach. These are access routes. They may be the routes you can use to get to the enemy or the routes they can use to get to you. These include how you move to your goal. Basically, *an identifiable route that approaches a position or location is an avenue of approach* to that location. In urban terrain, these avenues may be streets or open areas that provide relatively easy movement combined with many opportunities for cover and concealment.

In the experiment exercises, the BO is marked in a two-step process. First, you make a YELLOW circle around the desired BO position. Next, you place a YELLOW “X” in the center of the circle. Figure 2 provides an example. You do not need to indicate which team uses which position, as depicted in Figure 1. You do need to consider all potential threats to the moving squad and position the BO position appropriately. In our exercises you will not be allowed to use building interiors (or roofs), so all positions will be outside.

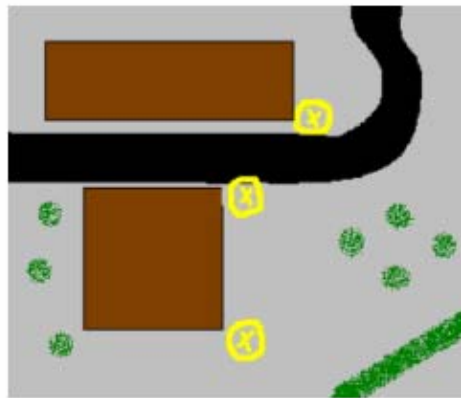


Figure 2. Bounding Overwatch Mark

PHASE 2: LANDING ZONES

Helicopters need a large amount of space, free of debris and obstacles, to land safely. Your goal is to locate and mark an appropriate *Landing Zone (LZ)* for a single helicopter. Based on your analysis of the map, you will select a space for the LZ, and then plan out a path for the platoon to follow when moving to and establishing the LZ. The general rule for clearance for an LZ is an open space that is 100 by 50 meters, or approximately the size of a football field. The landing area and marks (see below) should be centered in this open space.

The LZ should not be on an uneven slope - one that exceeds seven degrees, so the topography should be evaluated for that constraint. A rule of thumb is that if the surface drops one meter over a distance of 10 meters, it slopes too much. An inspection of the map contours or consideration of the “lay of the land” is used to make this decision.

Marking an LZ in this experiment, as in the Army, follows a specific protocol that is shown in Figure 3. Normally the Army marks an LZ using flags, smoke, or lights for night operations. In all LZ marking, four circular marks are arranged in a “Y” or “T” pattern (see Figure 3) with the long stem of the Y running in the direction of flight a helicopter should take when landing and taking off. The two marks at the top of the Y are 14 meters apart (remember that each full step in the VE is one meter). These marks indicate the landing threshold for the aircraft. From the top of the Y to the bottom of the stem is 21 meters. The central landing mark, where the helicopter lands, is placed 14 meters from the top two. The last mark is placed 7 meters further down. The center mark should be placed in the center of the clear landing area (the middle of the **100x50m field**). This means the center mark should be in the middle of the landing area, with 50 meters of clearance each way in the *direction of flight* and 25 meters clearance to each side. Figure 4 provides an example LZ mark on an enlarged, but correctly colored map.

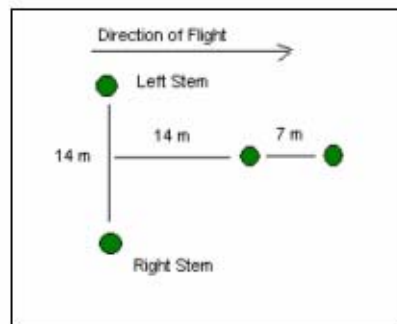


Figure 3. Landing Zone Marks

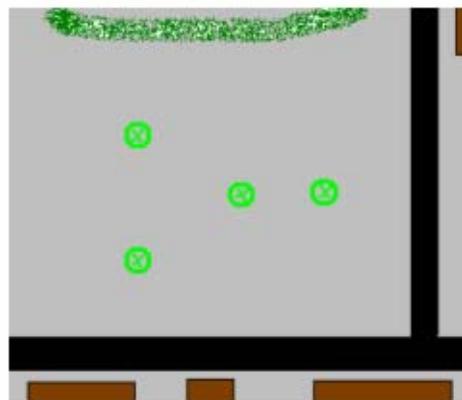


Figure 4. Example LZ Marks

PHASE 3: OBSERVATION FIRE POST

Once an LZ is located and marked, it needs to be protected from enemy fire. Your final task will be to mark Observation/Fire Posts (OFPs) around the LZ to indicate where platoon members can set up posts to cover threats or approaches to the LZ. You need to set up enough OFPs to provide complete coverage around the LZ (see OCOKA, above). Mark an OFP in the same way the other sites are marked, using RED to distinguish the OFP from LZ and BO marks. Figures 5 and 6 provide examples of the marks and positioning for the OFP sites.

Note that good OFPs can support each other with overlapping fields of fire, that means at least two positions can see each other and shoot at the same approaching force. They are not positioned so that they are shooting toward each other in order to shoot at the approaching forces.

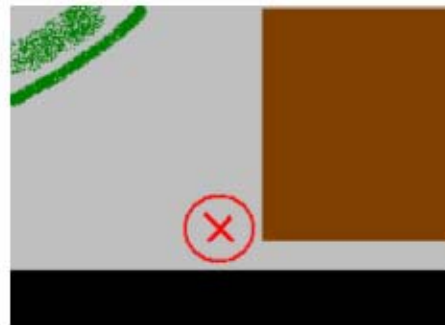


Figure 5. Observation/Fire Post Mark

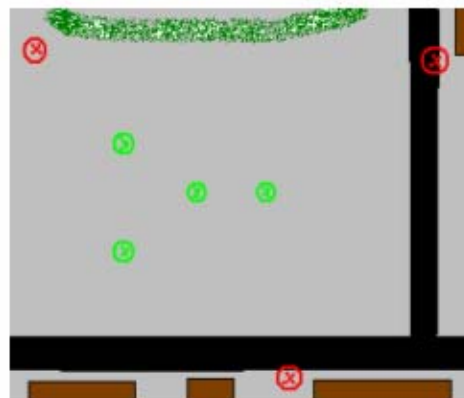


Figure 6. Example Observation/Fire Posts

Map Reading For Urban Terrain

Maps provide a scaled representation of environments using symbols and colors. In the MOULT context used in this research, the map is a topographical representation that is 1:5000 scale. This means that one meter on the map corresponds to 5000 meters on the actual terrain. On the map this means one centimeter equals 50 meters on the terrain. The map's legend contains the scale and symbols used on the map. The legend will also provide the contour interval (e.g. 10 meters, the difference in height of the terrain between each contour line), and information about the markings for roads, buildings, powerlines, railroads, etc.

Topographic maps use special symbols and colors to indicate features of the environment. To facilitate the identification of features on a map, topographical and cultural information is printed in different colors. The maps you will use in the exercises use the following colors and features:

Black indicates cultural (man-made) features such as roads, surveyed spot elevations, and all labels.

Red-Brown are combined to identify cultural features like buildings.

Blue identifies hydrography or water features such as lakes, swamps, rivers, and drainage. Solid blue indicates lakes or rivers, dotted or broken lines indicate occasional water like flood zones or intermittent streams.

Green identifies vegetation with military significance, such as woods, orchards, and vineyards. Denser green marks indicate denser vegetation. For example, dotted green lines might indicate sparse shrubs and trees, whereas solid green areas indicate thick forest regions.

A contour line is an imaginary boundary line that represents elevation, that is, vertical distance, above or below sea level. Index contour lines are thicker than others and are marked with an elevation. Moving from a smaller to a larger numbered index contour line would indicate an increase in elevation. The lines between the index contour lines (normally four) are thinner; each represents a change in elevation of 10 meters. Note that some variation in elevation does occur between contour lines, i.e., the terrain between these lines can vary in height to some degree.

Contour lines are helpful in showing geographical features of importance to dismounted soldiers. For example, contour lines that are evenly spaced and close together indicate a uniform, steep slope of the terrain. Such a high point might be used as an observation/fire post. The closer together the contour lines, the steeper the slope; the further apart the contour lines, the gentler the slope. Furthermore, the direction of the slope is indicated by the index contour lines. The contour lines in Figure 7 indicate a slope upward, from 100 meters to 150 meters.

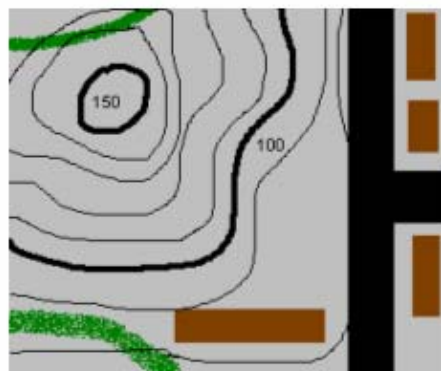


Figure 7. Example Contour Lines

The scale in Figure 7 is 1:5000, meaning the 3cm on the map between the 100 and 150 index contour lines indicates a rise of 50 meters elevation over 150 meters of distance. The slope between the 100 and 150 numbers is quite steep, especially where the contour lines are close together. Slopes can be interpreted using boundary estimates. For example, a rise of 100 meters over a distance of 100 meters would be a 45 degree slope (a 1:1 ratio), 50m rise over 100m (a 1:2 ratio) is a 27 degree slope, and a 10m over 100m (1:10 ratio) is a 6 degree slope. Other slopes can be evaluated by establishing the ratio and interpolating using these boundary values.

Since the LZ has to be in a flat area, an area with a 1:10 ratio or less is required. Note that different slopes can appear between contour lines, as they are only discrete measures of the terrain, and don't provide information about any change in elevation until the change exceeds the contour interval. On figure 7, an LZ could only be placed in the flat area below the 100 contour line, near the road and building at the bottom right of the figure.

SUMMARY

To review, your goal is to plan for the safe path to and protection of a helicopter landing zone. Each 12 minute exercise involves three phases 1) Bounding Overwatch placement (5 minutes), 2) Landing Zone identification and marking (4 minutes), and 3) Observation/Fire Post placement (3 minutes).

APPENDIX C: TEST FOR CONCEPTUAL UNDERSTANDING

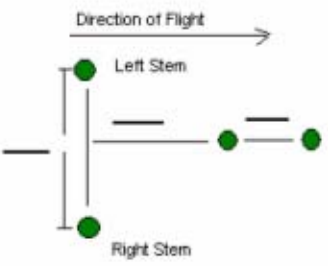
7.1 Test for IF Training

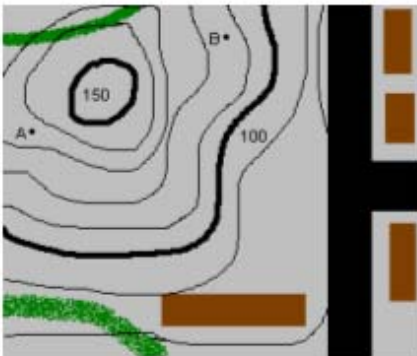
Participant #: _____

Date: _____



1. What color are observation fire posts?
A. Red B. Green C. Yellow D. White
2. What color are Bounding Overwatches?
A. Red B. Green C. Yellow D. White
3. What color are the Landing Zone markers?
A. Red B. Green C. Yellow D. White
4. What color of paint is used to erase marks?
A. Red B. Green C. Yellow D. White
5. When making marks in the environment, you should be aware of potential enemy threats within ____ meters of your position.
A. 10 B. 100 C. 200 D. 1000
6. Marks used to indicate where one squad should stop to cover another squad are called:
A. Observation Fire Posts B. Bounding Overwatches
C. CoverPoints D. Landing Zone Posts
7. On topographical maps, the colors red or brown are used to indicate:
A. Cultural features like buildings B. Lakes and streams
C. Roads and paths D. Vegetation (e.g., trees, bushes, etc.)
8. On topographical maps, the color black is used to indicate:
A. Cultural features like buildings B. Lakes and streams
C. Roads and paths D. Vegetation (e.g., trees, bushes, etc.)
9. On topographical maps, the color green is used to indicate:
A. Cultural features like buildings B. Lakes and streams
C. Roads and paths D. Vegetation (e.g., trees, bushes, etc.)
10. On the figure below, please mark the appropriate distances, in meters, for the Landing Zone.


11. What is the correct order, from first to last, of marks you should make during a exercise?
A. Observation Fire Posts, Bounding Overwatches, Landing Zone
B. Bounding Overwatches, Landing Zone, Observation Fire Posts
C. Bounding Overwatches, Observation Fire Posts, Landing Zone
D. Landing Zone, Observation Fire Posts, Bounding Overwatches

12. What is your primary goal during the exercises?	<p>A. Protect yourself from enemy fire</p> <p>B. Detect enemy locations</p> <p>C. Locate and mark a helicopter landing zone</p> <p>D. Shoot all enemy personnel and tanks</p>
13. The terrain slope ratio for a Landing Zone should not exceed what ratio between a rise in elevation and distance?	<p>A. 1:1 (100 meters rise over 100 meters distance)</p> <p>B. 1:2 (50 meters rise over 100 meters distance)</p> <p>C. 1:10 (10 meters rise over 100 meters distance)</p> <p>D. 1:100 (1 meter rise over 100 meters distance)</p>
14. In the figure below, which of the following statements is true?	<p>A. Point A is higher than point B</p> <p>B. Point B is higher than point A</p> <p>C. Point A and B are at the same elevation</p> <p>D. Cannot tell if point A is higher or lower than point B</p>
	
15. The purpose of an Observation/Fire Posts is to	<p>A. Provide fire coverage to all areas around a Landing Zone</p> <p>B. Provide markers for helicopter pilots</p> <p>C. Light up the area surrounding a Landing Zone</p> <p>D. Indicate where teams should stop while covering a moving team</p>
16. A Landing Zone requires what kind of space?	<p>A. Half of a football stadium.</p> <p>B. Half of a football field.</p> <p>C. An area approximately one hundred by fifty.</p> <p>D. Fifty to one hundred meters from buildings.</p>

APPENDIX D: MAP PLANNING EXERCISE

Participant: _____

Map Planning

Find an appropriate space for the LZ and plan a path to that area using OCOKA and the movement guidelines to select and mark the BO positions. Lay out the marks for the LZ, and the OFPs that will control access and protect the area. Mark all positions, appropriately. A small ruler will be furnished, along with colored markers.



Legend

Contour Interval: 10 meters

1:1000

1cm = 20 meters

 Buildings & Man-made Structures

 Vegetation

 Roads

 Water



APPENDIX E: MISSION SCENARIO PAPER MAPS

Scenario One

Participant Number



Legend

Contour Interval: 10 meters

1:5000m
1cm=50m



Buildings & Man-made Structures



Vegetation



Roads



Water



I

Scenario Two

Participant Number _____



Legend

Contour Interval: 10 meters

1:5000m

1cm=50m



Buildings & Man-made Structures



Vegetation



Roads



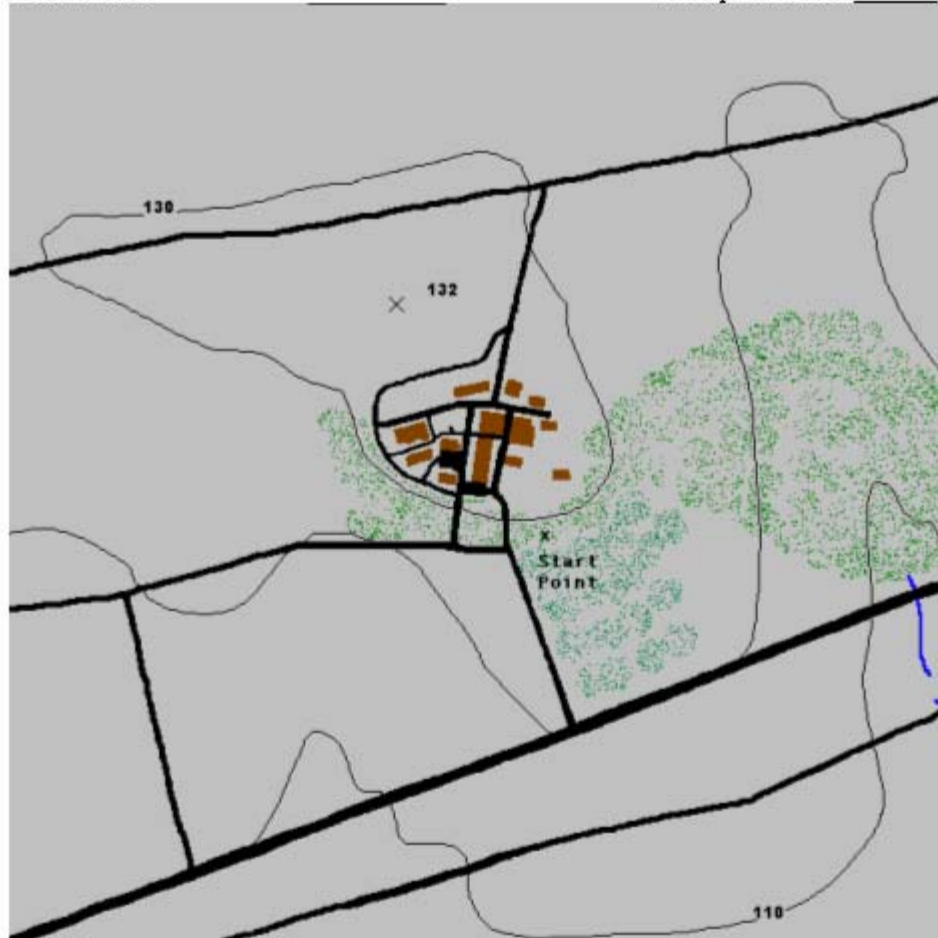
Water



I

Scenario Three

Participant Number _____



Legend

Contour Interval: 10 meters

15000m

1cm=50m



Buildings & Man-made Structures



Vegetation



Roads



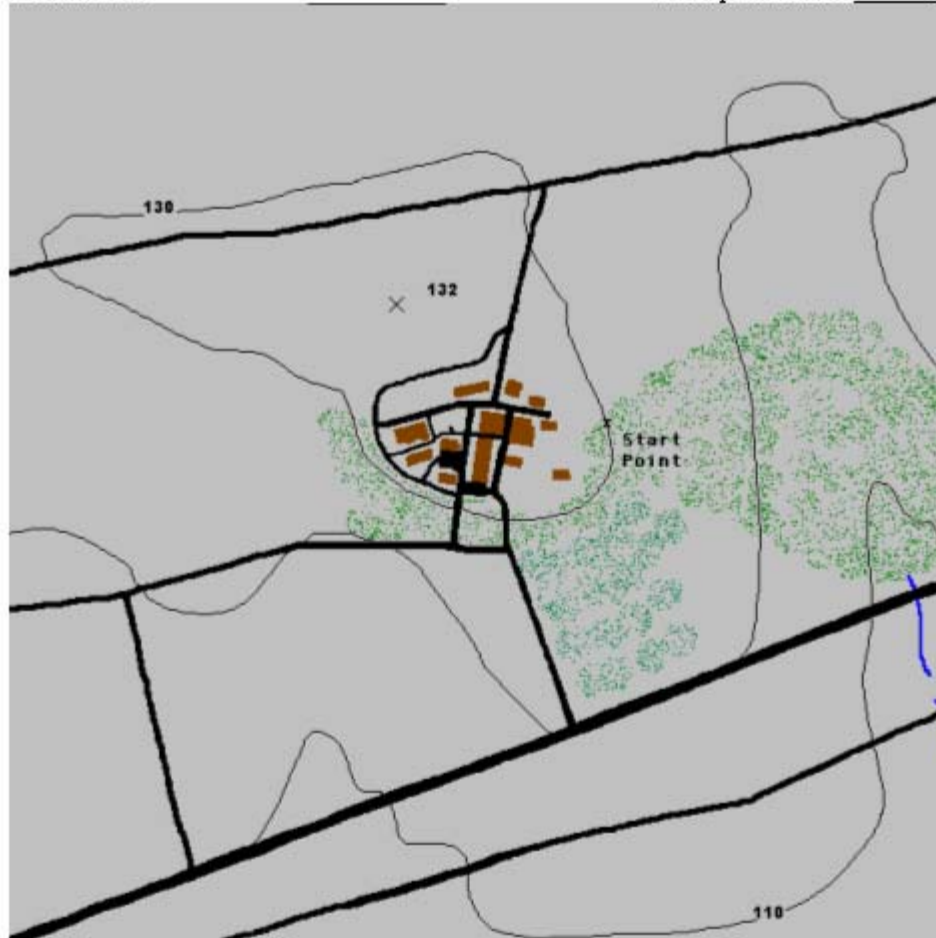
Water

1



Scenario Four

Participant Number _____



Legend

Contour Interval: 10 meters

1:5000m
1cm=50m



Buildings & Man-made Structures



Vegetation



Roads



Water



APPENDIX F: BIOGRAPHICAL QUESTIONNAIRE

Enter Experiment Number <input style="width: 50px;" type="text"/>	Enter Group Number <input style="width: 50px;" type="text"/>	Enter Participant Number <input style="width: 50px;" type="text"/>
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The experiment data is to be entered by the EXPERIMENTER ONLY.

Research Participant Information Questionnaire

Keyboard Directions: Position the cursor over the response that you want to select for a given question, then click the left mouse button to select it. If applicable, type in your answer. Use the scroll bar or PgDn button to move to the next set of (off-screen) questions. Please tell the experimenter when you are finished.

Instructions: Please click on the appropriate response.

1. Please type in your age.

Years Old
2. What is your gender?

Female

Male
3. Are you currently in your usual state of good fitness?

No

Yes
4. Type in the number of hours sleep you had last night. Use a decimal format, e.g. 7.5, 8.0, etc.

Hours Sleep
5. Have you ever experienced car or motion sickness?

No

Yes
6. How susceptible to motion or car sickness do you feel you are?

Not Susceptible

Very Mildly

Average

Very Highly
7. Do you have a good sense of direction?

No

Yes
8. Type in the number of hours per week that you use a computer. Use a decimal format, e.g. 7.5, 8.0, etc.

Hours per Week
9. My level of confidence in using computers is:

Low

Average

High
10. I enjoy playing video games (home or arcade):

Disagree

Unsure

Agree
11. I am _____ at playing video games:

Bad

Average

Good
12. Type in the number of hours per week that you play video games. Use a decimal format, e.g. 7.5, 8.0, etc.

Hours per Week
13. How many times in the last year have you experienced a virtual reality game or entertainment?

0

1

2

3

4

5

6

7

8

9

10

10+
14. Do you have a history of epilepsy or seizures?

No

Yes
15. Do you have normal or corrected to normal 20/20 vision?

No

Yes
16. Are you color blind?

No

Yes

END Research Participant Information Questionnaire Form: Please inform the experimenter that you are finished. DO NOT click any of the buttons located below the red line.

APPENDIX G: SIMULATOR SICKNESS QUESTIONNAIRE (SSQ)

Enter Experiment Number Enter Group Number Enter Participant Number Enter SSQ Number

The experiment data is to be entered by the EXPERIMENTER ONLY.

Simulator Sickness Questionnaire (SSQ)

Kennedy, Lane, Berbaum, and Lillenthal (1993)

Keyboard Directions: Position the cursor over the response that you want to select for a given question, then click the left mouse button to select it. Use the scroll bar or PgDn button to move to the next set of (off-screen) questions. Please tell the experimenter when you are finished.

Instructions: Please indicate the severity of symptoms that apply to you right now.

1. General Discomfort				
	None	Slight	Moderate	Severe
2. Fatigue				
	None	Slight	Moderate	Severe
3. Headache				
	None	Slight	Moderate	Severe
4. Eye Strain				
	None	Slight	Moderate	Severe
5. Difficulty Focusing				
	None	Slight	Moderate	Severe
6. Increased Salivation				
	None	Slight	Moderate	Severe
7. Sweating				
	None	Slight	Moderate	Severe
8. Nausea				
	None	Slight	Moderate	Severe
9. Difficulty Concentrating				
	None	Slight	Moderate	Severe
10. Fullness of Head				
	None	Slight	Moderate	Severe
11. Blurred Vision				
	None	Slight	Moderate	Severe
12. Dizzy (Eyes Open)				
	None	Slight	Moderate	Severe
13. Dizzy (Eyes Closed)				
	None	Slight	Moderate	Severe
14. Vertigo*				
	None	Slight	Moderate	Severe
15. Stomach Awareness				
	None	Slight	Moderate	Severe
16. Burping				
	None	Slight	Moderate	Severe

*Vertigo is a disordered state in which the person or his/her surroundings seem to whirl dizzily; giddiness.

END SSQ: Please inform the experimenter that you are finished. DO NOT click any of the buttons located below the red line.

APPENDIX H: PRESENCE QUESTIONNAIRE (PQ)

Enter Experiment Number
Enter Group Number
Enter Participant Number
Enter PQ Number

The experiment data is to be entered by the EXPERIMENTER ONLY.

Presence Questionnaire (PQ)

Witmer and Singer, (V.4: 2004)

Keyboard Directions: Position the cursor over the response that you want to select for a given question, then click the left mouse button to select it. Use the scroll bar or PgDn button to move to the next set of (off-screen) questions. Please tell the experimenter when you are finished..

Answer the questions below to characterize your experience in the virtual environment. For each question select the appropriate circle that most accurately describes your experience. Please consider all seven circles in making your selection, including those that do not have descriptive labels. Answer questions independently in the order that they appear. Do not skip questions or return to a previous question to change your answer.

WITH REGARD TO THE EXPERIENCED ENVIRONMENT

Questions 1 - 12 | Questions 13 - 24 | Questions 25 - 33 |

- How much were you able to control events?

☐
☐
☐
☐
☐
☐
☐

Not At All
Somewhat
Completely
- How responsive was the environment to actions that you initiated (or performed)?

☐
☐
☐
☐
☐
☐
☐

Not Responsive
Moderately Responsive
Completely Responsive
- How natural did your interactions with the environment seem?

☐
☐
☐
☐
☐
☐
☐

Extremely Artificial
Borderline
Completely Natural
- How much did the visual aspects of the environment involve you?

☐
☐
☐
☐
☐
☐
☐

Not At All
Somewhat
Completely
- How much did the auditory aspects of the environment involve you?

☐
☐
☐
☐
☐
☐
☐

Not At All
Somewhat
Completely
- How natural was the mechanism which controlled movement through the environment?

☐
☐
☐
☐
☐
☐
☐

Extremely Artificial
Borderline
Completely Natural
- How compelling was your sense of objects moving through space?

☐
☐
☐
☐
☐
☐
☐

Not At All
Moderately Compelling
Very Compelling
- How much did your experiences in the virtual environment seem consistent with your real world experiences?

☐
☐
☐
☐
☐
☐
☐

Not Consistent
Moderately Consistent
Very Consistent
- Were you able to anticipate what would happen next in response to the actions that you performed?

☐
☐
☐
☐
☐
☐
☐

Not At All
Somewhat
Completely
- How completely were you able to actively survey or search the environment using vision?

☐
☐
☐
☐
☐
☐
☐

Not At All
Somewhat
Completely
- How well could you identify sounds?

☐
☐
☐
☐
☐
☐
☐

Not At All
Somewhat
Completely
- How well could you localize sounds?

☐
☐
☐
☐
☐
☐
☐

Not At All
Somewhat
Completely

After clicking the "Top of List" button, click the tab labeled "Questions 13 - 24."

Top of List

Enter Experiment Number
Enter Group Number
Enter Participant Number
Enter PQ Number

The experiment data is to be entered by the EXPERIMENTER ONLY.

Presence Questionnaire (PQ)

Witmer and Singer, (V.4: 2004)

Keyboard Directions: Position the cursor over the response that you want to select for a given question, then click the left mouse button to select it. Use the scroll bar or PgDn button to move to the next set of (off-screen) questions. Please tell the experimenter when you are finished..

Answer the questions below to characterize your experience in the virtual environment. For each question select the appropriate circle that most accurately describes your experience. Please consider all seven circles in making your selection, including those that do not have descriptive labels. Answer questions independently in the order that they appear. Do not skip questions or return to a previous question to change your answer.

WITH REGARD TO THE EXPERIENCED ENVIRONMENT

Questions 1 - 12 Questions 13 - 24 Questions 25 - 33

13. How well could you actively survey or search the virtual environment using touch?

Not At All Somewhat Completely

14. How compelling was your sense of moving around inside the virtual environment?

Not Compelling Moderately Compelling Very Compelling

15. How closely were you able to examine objects?

Not At All Pretty Closely Very Closely

16. How well could you examine objects from multiple viewpoints?

Not At All Somewhat Extensively

17. How well could you move or manipulate objects in the virtual environment?

Not At All Somewhat Extensively

18. How involved were you in the virtual environment experience?

Not Involved Mildly Involved Completely Engrossed

19. How much delay did you experience between your actions and expected outcomes?

No Delays Moderate Delays Long Delays

20. How quickly did you adjust to the virtual environment experience?

Not At All Slowly Less Than One Minute

21. How proficient in moving and interacting with the virtual environment did you feel at the end of the experience?

Not Proficient Reasonably Proficient Very Proficient

22. How much did the visual display quality interfere or distract you from performing assigned tasks or required activities?

Not At All Interfered Somewhat Prevented Task Performance

23. How much did the control devices interfere with the performance of assigned tasks or with other activities?

Not At All Interfered Somewhat Interfered Greatly

24. How well could you concentrate on the assigned tasks or required activities rather than on the mechanisms used to perform those tasks or activities?

Not At All Somewhat Completely

After clicking the "Top of List" button, click the tab labeled "Questions 25 - 33."

Top of List

Enter Experiment Number	Enter Group Number	Enter Participant Number	Enter PQ Number
<input style="width: 50px;" type="text"/>	<input style="width: 50px;" type="text"/>	<input style="width: 50px;" type="text"/>	<input style="width: 50px;" type="text"/>

The experiment data is to be entered by the EXPERIMENTER ONLY.

Presence Questionnaire (PQ)

Witmer and Singer, (V.4: 2004)

Keyboard Directions: Position the cursor over the response that you want to select for a given question, then click the left mouse button to select it. Use the scroll bar or PgDn button to move to the next set of (off-screen) questions. Please tell the experimenter when you are finished..

Answer the questions below to characterize your experience in the virtual environment. For each question select the appropriate circle that most accurately describes your experience. Please consider all seven circles in making your selection, including those that do not have descriptive labels. Answer questions independently in the order that they appear. Do not skip questions or return to a previous question to change your answer.

WITH REGARD TO THE EXPERIENCED ENVIRONMENT

Questions 1 - 12
Questions 13 - 24
Questions 25 - 33

25. How completely were your senses engaged in this experience?

26. How easy was it to identify objects through physical interaction; like touching an object, walking over a surface, or bumping into a wall or object?

27. Were there moments during the virtual environment experience when you felt completely focused on the task or environment?

28. How easily did you adjust to the control devices used to interact with the virtual environment?

29. Was the information provided through different senses in the virtual environment (e.g., vision, hearing, touch) consistent?

30. To what extent did you feel completely surrounded by and enveloped by the virtual environment?

31. As you moved through the virtual environment and interacted with it, did you feel like you were inside the virtual environment, affecting or being affected by objects and events in that environment?

32. How much did your experience in the virtual environment seem like you were in a real place, able to directly sense and interact with the environment?

33. In the virtual environment, how strong was your sense of "being there"?

End PQ: Please inform the experimenter that you are finished. DO NOT click the buttons below the red line.

APPENDIX I: IMMERSIVE TENDENCIES QUESTIONNAIRE (ITQ)

Enter Experiment Number
Enter Group Number
Enter Participant Number

The experiment data is to be entered by the EXPERIMENTER ONLY.

Immersive Tendencies Questionnaire (ITQ)

Witmer and Singer, (1993)

Keyboard Directions: Position the cursor over the response that you want to select for a given question, then click the left mouse button to select it. Use the scroll bar or PgDn button to move to the next set of (off-screen) questions. Please tell the experimenter when you are finished.

Indicate your preferred answer by clicking the appropriate circle of the seven point scale. Please consider the entire scale when making your responses, as the intermediate levels may apply. For example, if your response is once or twice, the second circle from the left should be selected. If your response is many times but not extremely often, then the sixth (or second circle from the right) should be selected.

Questions 1 - 12
Questions 13 - 24
Questions 25 - 34

- Do you easily become deeply involved in movies or tv dramas?

NEVER
OCCASIONALLY
OFTEN
- Do you ever become so involved in a television program or book that people have problems getting your attention?

NEVER
OCCASIONALLY
OFTEN
- How mentally alert do you feel at the present time?

NOT ALERT
MODERATELY
FULLY ALERT
- Do you ever become so involved in a movie that you are not aware of things happening around you?

NEVER
OCCASIONALLY
OFTEN
- How frequently do you find yourself closely identifying with the characters in a story line?

NEVER
OCCASIONALLY
OFTEN
- Do you ever become so involved in a video game that it is as if you are inside the game rather than moving a joystick and watching the screen?

NEVER
OCCASIONALLY
OFTEN
- What kind of books do you read most frequently? (CHECK ONE ITEM ONLY!)

Spy novels
Adventure novels
Westerns
Biographies
Fantasies
Romance novels
Mysteries
Autobiographies
Science fiction
Historical novels
Other fiction
Other non-fiction
- How physically fit do you feel today?

NOT FIT
MODERATELY FIT
EXTREMELY FIT
- How good are you at blocking out external distractions when you are involved in something?

NOT VERY GOOD
SOMEWHAT GOOD
VERY GOOD
- When watching sports, do you ever become so involved in the game that you react as if you were one of the players?

NEVER
OCCASIONALLY
OFTEN
- Do you ever become so involved in a daydream that you are not aware of things happening around you?

NEVER
OCCASIONALLY
OFTEN
- Do you ever have dreams that are so real that you feel disoriented when you awake?

NEVER
OCCASIONALLY
OFTEN

After clicking the "Top of List" button, click the tab labeled "Questions 13 - 24."

Top of List

Enter Experiment Number
Enter Group Number
Enter Participant Number

The experiment data is to be entered by the EXPERIMENTER ONLY.

Immersive Tendencies Questionnaire (ITQ)

Witmer and Singer, (1993)

Keyboard Directions: Position the cursor over the response that you want to select for a given question, then click the left mouse button to select it. Use the scroll bar or PgDn button to move to the next set of (off-screen) questions. Please tell the experimenter when you are finished.

Indicate your preferred answer by clicking the appropriate circle of the seven point scale. Please consider the entire scale when making your responses, as the intermediate levels may apply. For example, if your response is once or twice, the second circle from the left should be selected. If your response is many times but not extremely often, then the sixth (or second circle from the right) should be selected.

Questions 1 - 12
Questions 13 - 24
Questions 25 - 34

13. When playing sports, do you become so involved in the game that you lose track of time?

NEVER
OCCASIONALLY
OFTEN

14. How well do you concentrate on enjoyable activities?

NOT AT ALL
MODERATELY WELL
VERY WELL

15. How often do you play arcade or video games? (OFTEN should be taken to mean every day or every two days, on average.)

NEVER
OCCASIONALLY
OFTEN

16. Have you ever gotten excited during a chase or fight scene on TV or in the movies?

NEVER
OCCASIONALLY
OFTEN

17. Have you ever gotten scared by something happening on a TV show or in a movie?

NEVER
OCCASIONALLY
OFTEN

18. Have you ever remained apprehensive or fearful long after watching a scary movie?

NEVER
OCCASIONALLY
OFTEN

19. Do you ever become so involved in doing something that you lose all track of time?

NEVER
OCCASIONALLY
OFTEN

20. On average, how many books do you read for enjoyment in a month?

NONE
ONE
TWO
THREE
FOUR
FIVE
MORE

21. Do you ever get involved in projects or tasks, to the exclusion of other activities?

NEVER
OCCASIONALLY
OFTEN

22. How easily can you switch attention from the activity in which you are currently involved to a new and completely different activity?

NOT SO EASILY
FAIRLY EASILY
QUITE EASILY

23. How often do you try new restaurants or new foods when presented with the opportunity?

NEVER
OCCASIONALLY
FREQUENTLY

24. How frequently do you volunteer to serve on committees, planning groups, or other civic or social groups?

NEVER
SOMETIMES
FREQUENTLY

After clicking the "Top of List" button, click the tab labeled "Questions 25 - 34."

Top of List

Enter Experiment Number
Enter Group Number
Enter Participant Number

The experiment data is to be entered by the EXPERIMENTER ONLY.

Immersive Tendencies Questionnaire (ITQ)

Witmer and Singer, (1993)

Keyboard Directions: Position the cursor over the response that you want to select for a given question, then click the left mouse button to select it. Use the scroll bar or PgDn button to move to the next set of (off-screen) questions. Please tell the experimenter when you are finished.

Indicate your preferred answer by clicking the appropriate circle of the seven point scale. Please consider the entire scale when making your responses, as the intermediate levels may apply. For example, if your response is once or twice, the second circle from the left should be selected. If your response is many times but not extremely often, then the sixth (or second circle from the right) should be selected.

Questions 1 - 12
Questions 13 - 24
Questions 25 - 34

25. How often do you try new things or seek out new experiences?

☐ ☐ ☐ ☐ ☐ ☐ ☐

☐ NEVER ☐ OCCASIONALLY ☐ OFTEN

26. Given the opportunity, would you travel to a country with a different culture and a different language?

☐ ☐ ☐ ☐ ☐ ☐ ☐

☐ NEVER ☐ MAYBE ☐ ABSOLUTELY

27. Do you go on carnival rides or participate in other leisure activities (horse back riding, bungee jumping, snow skiing, water sports) for the excitement of thrills that they provide?

☐ ☐ ☐ ☐ ☐ ☐ ☐

☐ NEVER ☐ OCCASIONALLY ☐ OFTEN

28. How well do you concentrate on disagreeable tasks?

☐ ☐ ☐ ☐ ☐ ☐ ☐

☐ NOT AT ALL ☐ MODERATELY WELL ☐ VERY WELL

29. How often do you play games on computers?

☐ ☐ ☐ ☐ ☐ ☐ ☐

☐ NOT AT ALL ☐ OCCASIONALLY ☐ FREQUENTLY

30. How many different video, computer, or arcade games have you become reasonably good at playing?

☐ ☐ ☐ ☐ ☐ ☐ ☐

☐ NONE ☐ ONE ☐ TWO ☐ THREE ☐ FOUR ☐ FIVE ☐ MORE

31. Have you ever felt completely caught up in an experience, aware of everything going on and completely open to all of it?

☐ ☐ ☐ ☐ ☐ ☐ ☐

☐ NEVER ☐ OCCASIONALLY ☐ FREQUENTLY

32. Have you ever felt completely focused on something, so wrapped up in that one activity that nothing could distract you?

☐ ☐ ☐ ☐ ☐ ☐ ☐

☐ NOT AT ALL ☐ OCCASIONALLY ☐ FREQUENTLY

33. How frequently do you get emotionally involved (angry, sad, or happy) in news stories that you see, read, or hear?

☐ ☐ ☐ ☐ ☐ ☐ ☐

☐ NEVER ☐ OCCASIONALLY ☐ OFTEN

34. Are you easily disturbed when involved in an activity or working on a task?

☐ ☐ ☐ ☐ ☐ ☐ ☐

☐ NEVER ☐ OCCASIONALLY ☐ OFTEN

End ITQ: Please inform the experimenter that you are finished. DO NOT click the buttons below the red line.

APPENDIX J: METHODOLOGY FOR IMPLEMENTING DECISION ANALYSIS THEORY IN INSTRUCTIONAL DESIGN

This appendix describes the decision analysis approach to analyzing the data from the present CAS experiment. First, in order to have a basis of comparison with the qualitatively and quantitatively different outcomes measures (effectiveness in points and efficiency in points/second), z scores were calculated in MS Excel from the raw effectiveness and efficiency data after filtering out scores more than 1.5 standard deviations from the mean.

Second, the subtask decision trees were constructed (see Figures 16-18) using the PrecisionTree module. Each sub branch for each strategy (experimental condition) represents an outcome measurement expected value – effectiveness or efficiency. The risk neutral additive utility function (Clemen & Reilly, 2001) was then used to determine the expected value of each strategy for each subtask:

$$U(x_1, \dots, x_m) = \sum_{i=1}^m k_i U_i(x_i) \quad (1)$$

Here,

$$U(\text{Effectiveness, Time Efficiency}) = k_E U(\text{Effectiveness}) + k_I U(\text{Time Efficiency}) \quad (2)$$

The overall decision for each subtask tree was determined by maximizing the mean of the expected utility function from each of the six branches.

Third, the @Risk module was used to model the uncertainty necessary to build a requisite decision model (Clemen, 2001). The uncertainty was modeled by fitting probability distribution functions of the z scores (e.g., Figure 20) using the Maximum Likelihood Estimators method

from the available @Risk distribution function library for those distributions which had a bounded, but unknown lower limit and an unknown upper limit.

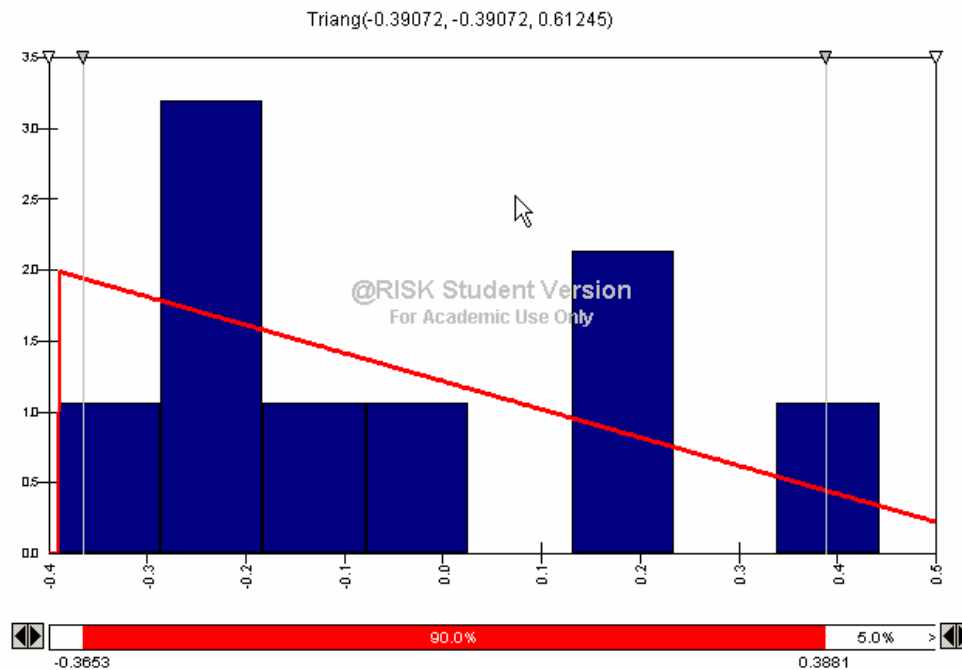


Figure 20. Fitted curve for LZ efficiency – Audio strategy

This eliminated from consideration those theoretical distributions which could have produced a negative sample (such as the Normal curve), which is nonsensical when time is being considered. Because the mean was the statistic of interest and the Kolmogorov-Smirnov (K-S) Goodness of Fit (GOF) test focuses in the middle of the distribution (Palisade, 2004b, 2005), the calculated K-S GOF statistic was used to rank order the eligible parameterized distributions. To ensure GOF, if the highest ranked GOF statistic was less than the critical value (alpha) of .05 for that distribution (or a lower ranking distribution if not available for the highest ranking distribution),

then the highest ranked parameterized distribution was accepted as the best fit. If no critical value was available, the highest ranking distribution's P-P graph (which plots the fitted p-value with the input p-value or how well the fitted distribution approximates the real world data, e.g., Figure 21) was visually inspected to ensure approximate linearity for adequate GOF (see Palisade, 2004b).

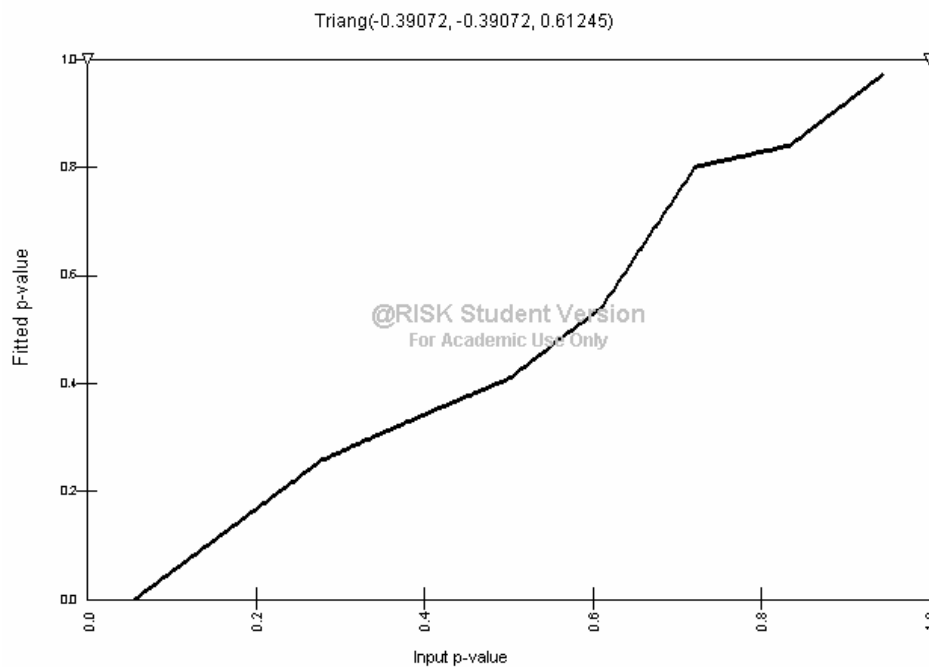


Figure 21. P-P plot for LZ Efficiency – Audio strategy showing approximate linearity

In all cases, the theoretical parameterized distributions were deemed to have an acceptable GOF. Table 11 shows the parameterized probability distributions used for the various branches. The mathematical forms of these distributions can be found in the software documentation (Palisade, 2005).

Table 11. Mission 4 best fit probability density functions with parameters characterizing outcomes

Outcome	Fitted Probability Distribution Function
M4 BO Effectiveness - No Strategy	Uniform(0.28988, 1.1857)
M4 BO Efficiency - No Strategy	Expon(0.92949, 1.12197)
M4 BO Effectiveness - Arrow	Triang(1.7457, 1.1581, 1.1581)
M4 BO Efficiency - Arrow	Lognorm2(1.7711, 0.074835, 6.3276)
M4 BO Effectiveness - Audio	Triang(0.15459, 0.81469, 0.81469)
M4 BO Efficiency - Audio	Uniform(0.9175, 0.76908)
M4 BO Effectiveness - Text	Triang(1.3981, 1.0114, 1.0114)
M4 BO Efficiency - Text	Weibull(5.0302, 1.7189, Shift(1.8423))
M4 BO Effectiveness - Arrow + Audio	Weibull(20.345, 15.762, Shift(15.469))
M4 BO Efficiency - Arrow + Audio	Rayleigh(0.66232, Shift(1.25878))
M4 BO Effectiveness - Audio + Text	BetaGeneral(0.33168, 0.29483, 1.3561, 1.2348)
M4 BO Efficiency - Audio + Text	Lognorm2(9.4881, 0.000040019, Shift(13202))
M4 LZ Effectiveness - No Strategy	Weibull(6.2269, 3.0175, Shift(2.8031))
M4 LZ Efficiency - No Strategy	Weibull(1.4973, 0.34592, Shift(0.64804))
M4 LZ Effectiveness - Arrow	Weibull(18.192, 4.4455, Shift(3.8485))
M4 LZ Efficiency - Arrow	Loglogistic(0.59037, 0.33974, 2.6996)
M4 LZ Effectiveness - Audio	Triang(1.3006, 1.4071, 1.4071)
M4 LZ Efficiency - Audio	Triang(-0.39072, -0.39072, 0.61245)
M4 LZ Effectiveness - Text	BetaGeneral(0.32112, 0.30792, 1.0322, 0.80836)
M4 LZ Efficiency - Text	Pearson5(1.972, 0.58594, Shift(0.74352))
M4 LZ Effectiveness - Arrow + Audio	Rayleigh(0.93528, Shift(0.7961))
M4 LZ Efficiency - Arrow + Audio	Weibull(1.5371, 0.26178, Shift(0.27425))
M4 LZ Effectiveness - Audio + Text	Weibull(5.3499, 2.8837, Shift(2.5596))
M4 LZ Efficiency - Audio + Text	Expon(0.27798, Shift(0.46794))
M4 OF Effectiveness - No Strategy	Weibull(16.46, 5.5103, Shift(5.175))
M4 OF Efficiency - No Strategy	Triang(-0.93914, -0.93914, 1.4963)
M4 OF Effectiveness - Arrow	BetaGeneral(0.35788, 0.25361, 0.19625, 0.64684)
M4 OF Efficiency - Arrow	Lognorm2(1.605, 0.072531, 5.293, Shift(5.293))
M4 OF Effectiveness - Audio	Triang(0.90398, 0.9036, 0.9036)
M4 OF Efficiency - Audio	Loglogistic(1.05756, 0.96494, 2.0599)
M4 OF Effectiveness - Text	Weibull(3.1717, 1.1385, Shift(0.85476))
M4 OF Efficiency - Text	Triang(-1.7222, -0.037566, -0.037566)
M4 OF Effectiveness - Arrow + Audio	Weibull(12.027, 5.4365, Shift(5.0336))
M4 OF Efficiency - Arrow + Audio	Lognorm2(2.1456, 0.046336, Shift(9.0446))
M4 OF Effectiveness - Audio + Text	Triang(1.1776, 0.72973, 0.72973)
M4 OF Efficiency - Audio + Text	Invgauss(0.83378, 6.46508, Shift(1.17902))

For example, the Loglogistic(0.59037, 0.33974, 2.6996) function characterizing the M4 LZ Efficiency - arrow data (where the first number α is a continuous location parameter, the second number β is a continuous scale parameter, and the third number γ is a continuous shape parameter) is mathematically expressed as:

$$\begin{aligned} \text{Loglogistic}(\alpha, \beta, \gamma) &= \frac{\alpha t^{(\alpha-1)}}{\beta(1+t^\alpha)^2} & \text{with } t &= \frac{x-\gamma}{\beta} \\ &= \frac{.59037 t^{(.59037-1)}}{.33974(1+t^{.59037})^2} & \text{with } t &= \frac{x-2.6996}{.33974} \end{aligned} \quad (6)$$

A simulation of the LZ subtask equations from Table 11 was then run which calculated the LZ expected utility where the scaling factor $k_I = 1.0$, Latin Hypercube random sampling was used, a random random number generator seed was used, and the simulation was set to automatically stop when key values (percent change in percent change, percent change in mean, and percent change in standard deviation) converged within an arbitrarily-determined 0.1%. Figure 22 shows the metamodel determined by curve fitting the output data from this simulation.

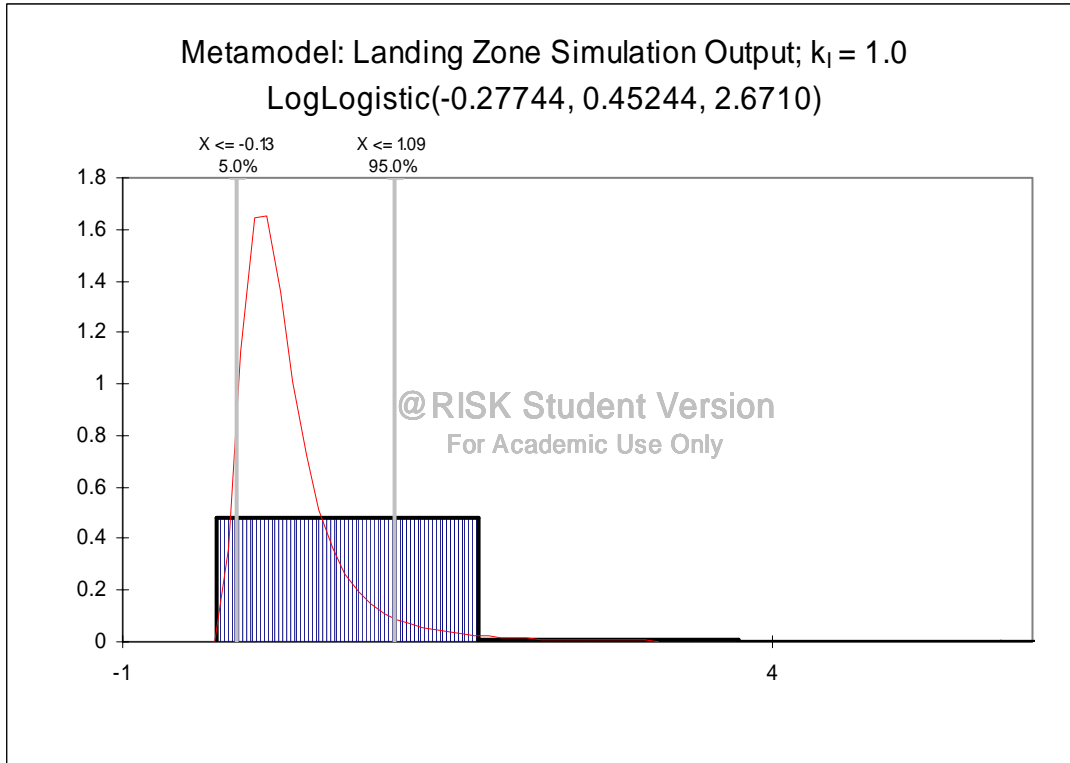


Figure 22. Graph of the fitted metamodel using LZ simulation data for $k_1 = 1.0$

This metamodel could then be used in the future as an approximation of the LZ simulation without having to run the simulation again. The metamodel, I argue, is the mathematical function approximation of the OSS_A . Therefore, the result of the underlying model interactions for LZ efficiency (assuming infinite economic resources) is approximated by:

$$OSS_A \text{ model} = f(\text{learner model, goal model, economic model, time model})$$

$$= \text{LogLogistic}(-0.27744, 0.45244, 2.6710)$$

$$= \frac{\alpha t^{\alpha-1}}{\beta(1+t^\alpha)^2} \quad \text{with} \quad t = \frac{x-\gamma}{\beta}$$

$$= \frac{-.27744t^{-.27744-1}}{.45244(1+t^{-.27744})^2} \quad \text{with} \quad t = \frac{x-(2.6710)}{.45244} \quad (7)$$

Fourth, the RiskOptimizer module was used to optimize the utility function by stochastically simulating the underlying uncertainty model again. For this simulation, Latin Hypercube stratified sampling was used in order to accurately recreate the probability distributions specified by the distribution functions in fewer iterations when compared with Monte Carlo sampling (Palisade, 2004b). This was done by adjusting the expected utility value from each CAS branch subject to the arbitrary constraints that each z score be between -5 and +5. A DecisionTools proprietary genetic algorithm was set to use the default settings for the recipe solution method, a mutation rate of 0.1, a crossover rate of 0.5, and default operators to close in on the “survival of the fittest” values. The simulation was arbitrarily set to run until the actual difference between the last three iterations was less than .01%. The stop tolerance for these iterations was determined automatically (default). The simulation was then started and ran until the stopping rule criterion was met.

The genetic algorithm solves mathematical programming optimization problems (Palisade, 2004a) which have the following or related forms (Greenberg, 2004):

$$\text{Maximize } f(x): x \text{ in } X, g(x) \leq 0, h(x) = 0,$$

where X is a subset of R^n and is in the domain of the real-valued functions, f , g and h .

The relations, $g(x) \leq 0$ and $h(x) = 0$ are called *constraints*, and f is called the *objective*

function. A point x is *feasible* if it is in X and satisfies the constraints: $g(x) \leq 0$ and $h(x) = 0$. A point x^* is *optimal* if it is feasible and if the value of the objective function is not less than that of any other feasible solution: $f(x^*) \geq f(x)$ for all feasible x . The *sense of optimization* is presented here as *maximization*, but it could just as well be *minimization*, with the appropriate change in the meaning of optimal solution: $f(x^*) \leq f(x)$ for all feasible x .

Therefore, for the CAS LZ efficiency exemplar problem:

$$OSS_A = \max \left[\frac{-.27744t^{-.27744-1}}{.45244(1+t^{-.27744})^2} \right] \quad \text{with} \quad t = \frac{x - (2.6710)}{.45244} \quad (8)$$

This instantiates the OLM model and the analytical component of the Unified Field Theory of Guided Learning. If valid, it may now be possible to mathematically prescribe instruction down to the stimulus level and then generate the optimal learning environment.

APPENDIX K: INDEPENDENT REVIEW BOARD APPROVAL LETTER



Office of Research

November 6, 2003

Glenn Martin
Institute for Simulation and Training
3280 Progress Drive
Orlando, Florida 32826

Dear Mr. Martin:

With reference to your protocol entitled, "Training in Virtual Environments: Instructional Features II," I am enclosing for your records the approved, executed document of the UCFIRB Form you had submitted to our office.

Please be advised that this approval is given for one year. Should there be any addendums or administrative changes to the already approved protocol, they must also be submitted to the Board. Changes should not be initiated until written IRB approval is received. Adverse events should be reported to the IRB as they occur. Further, should there be a need to extend this protocol, a renewal form must be submitted for approval at least one month prior to the anniversary date of the most recent approval and is the responsibility of the investigator (UCF).

Should you have any questions, please do not hesitate to call me at 823-2901.

Please accept our best wishes for the success of your endeavors.

Cordially,

A handwritten signature in cursive script, appearing to read "Chris Grayson".

Chris Grayson
Institutional Review Board (IRB)

Copies: Barry Wick
IRB File

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